

**SECTION 09900
PAINTS AND COATINGS**

- B. ICI Devoe, Louisville, KY.
- C. Raven Lining Systems, Tulsa, OK.
- D. Sherwin Williams, Cleveland, OH.
- E. NSP Specialty Products, Pinehurst, NC.
- F. Tnemec Coatings, Kansas City, MO.
- G. Madison Chemical Industries, Inc., Rancho Santa Margarita, CA.

2.02 COATING MATERIALS

- A. Quality: Manufacturer's highest quality products and suitable for intended use.
- B. Materials Including Primer and Finish Coat: Product by same paint manufacturer.
- C. Thinners, Cleaners, Driers and Other Additives: As recommended by paint manufacturer of the particular coating.
- D. Epoxy Primer: Polyamide or polyamine, anticorrosive converted epoxy primer containing rust inhibitive pigments.
- E. NSF Epoxy (AWWA D102-03 I.C.S. 1): Self-priming epoxy coatings intended for potable water contact and certified to conform to NSF Standard 61.
- F. Intermediate Epoxy: Two-component epoxy capable of 4 to 6 MDFT per coat, as recommended by the coating system manufacturer.
- G. Polyurethane Enamel: Two-component, aliphatic or acrylic based polyurethane; semi-gloss finish.
- H. NSF Polyurethane: Plural-component, self-priming polyurethane lining, intended for potable water contact and certified to conform to NSF Standard 61. Use 100% solids, zero VOC, polyurethane formulations such as Polibrid 705 (Elastomeric) as manufactured by Carboline Company; Corrocate II by Madison Chemical Industries (non-elastomeric); or approved equal.
- I. Caulking: As recommended by the coating manufacturer for the service condition.

2.03 COLORS

- A. Formulate with colorants free of lead and lead compounds.
- B. Exterior tank color to be determined during shop drawing phase of project and approved by the OWNER.
- C. Proprietary identification of colors is for identification only; selected manufacturer may supply matches.

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2.04 DISINFECTION MATERIALS

- A. Disinfection materials shall conform to requirements of AWWA C652 and ADEQ Bulletin No. 8.

PART 3 EXECUTION

3.01 INSPECTION

- A. Thoroughly examine surfaces scheduled to be painted prior to commencement of Work. Report in writing to OWNER, any condition that may potentially affect proper application. Do not commence until such defects have been corrected.
- B. Correct defects and deficiencies in surfaces which may adversely affect work of this Section.
- C. Notify ENGINEER and OWNER at least 7 days prior to start of coating preparation and application.

3.02 PROTECTION

- A. Adequately protect other surfaces from paint and damage. Repair damage as a result of inadequate or unsuitable protection.
- B. Furnish sufficient drop cloths, shields, and protective equipment to prevent spray or droppings from fouling surfaces not being painted and in particular, surfaces within storage and preparation area.
- C. Place cotton waste, cloths, and material which may constitute a fire hazard in closed metal containers and remove daily from Site.
- D. Remove items not painted prior to painting operations. Items are to be carefully stored, cleaned, and replaced on completion of work in each area.
- E. CONTRACTOR shall employ forced air ventilation during application of interior coatings. After completion of interior coatings, proper curing procedures shall be followed. Adequate cure time shall be allowed prior to performing disinfection and prior to filling tank for leak test.

3.03 PREPARATION

- A. Remove mildew, by scrubbing with solution of tri-sodium phosphate and bleach. Rinse with clean water and allow surface to dry completely.
- B. Aluminum surfaces: Remove surface contamination by steam, high pressure water, or solvent washing. Apply etching primer or acid etch. Apply paint immediately if acid etching.
- C. Copper surfaces requiring paint finish: Remove contamination by steam, high pressure water, or solvent washing. Apply vinyl etch primer or acid etch. Apply paint immediately if acid etching.
- D. Galvanized surfaces: Remove surface contamination and oils and wash with solvent. Apply coat of etching type primer.

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- E. Zinc coated surfaces: Remove surface contamination and oils and prepare for priming in accordance with metal manufacturer's recommendations.
- F. Concrete and concrete masonry:
 - 1. Remove dirt, loose mortar, scale, powder, and other foreign matter. Remove oil and grease with solution of trisodium phosphate, rinse well and allow to thoroughly dry.
 - 2. Remove stains caused by weathering of corroding metals with solution of sodium metasilicate after being thoroughly wetted with water. Allow to thoroughly dry.
- G. Iron and steel surfaces:
 - 1. Cleaning methods: Conform to applicable requirements of SSPC.
 - a. Solvent cleaning: SSPC-SP1.
 - b. Power tool cleaning: SSPC-SP3.
 - c. Commercial blast cleaning: SSPC-SP6
 - d. Brush-off blast cleaning: SSPC-SP7.
 - e. Near-white blast cleaning: SSPC-SP10.
 - 2. Blast cleaning requirements: The interior surfaces of reservoir shall be blast cleaned to near-white metal (SSPC-SP10), until all surfaces are free of contaminants. The exterior surface of reservoir shall be commercial blast cleaned (SSPC-SP6), until all surfaces are free of contaminants.
 - 3. Removal of materials such as grease and oil: SSPC-SP1. Apply treatment of phosphoric acid solution; ensuring weld joints, bolts and nuts are similarly cleaned. Prime surfaces to indicate defects, if any. Paint after defects have been remedied.
 - 4. Surface irregularities from blasting shall be approximately 25% of total paint system dry mil thickness, or as specified elsewhere.
- H. Prepare surfaces to be finished in conformance to recommendations of finish manufacturer.

3.04 SURFACE PREPARATION FOR WELDED STEEL RESERVOIRS

- A. Slag and weld metal accumulation not removed by tank fabricator, erector, or installer shall be removed by grinding. All sharp edges shall be peened, ground, or otherwise blunted as recommended by coating manufacturer.
- B. Field blast cleaning for all surfaces shall be with dry abrasive unless otherwise approved.
- C. Maximum particle size of abrasives used in blast cleaning shall be that which will produce a profile in accordance with recommendations of manufacturer of specified coating system.
- D. Abrasive used in field blast cleaning operations shall be new and free of contaminants that would interfere with adhesion or performance of coating system. For unconfined blasting operations, abrasives shall meet air quality board regulatory requirements. Abrasives shall not be reused unless they are free of contamination and approved by OWNER.

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- E. During blast cleaning operations, caution shall be exercised to insure that existing coatings or paint are not exposed to abrasion from blast cleaning. Any existing coatings thus damaged shall be restored to their previous state.
- F. Keep Work area in clean condition. Do not permit blasting materials to accumulate and constitute nuisance or hazard to prosecution of work or operation of existing facilities.
- G. If necessary, blast cleaned surfaces shall be dry-cleaned prior to application of specified coating or paint. No coating or paint shall be applied over damp surfaces.

3.05 APPLICATION FOR WELDED STEEL RESERVOIRS

- A. Coating and paint application shall conform to requirements of Steel Structures Painting Council Painting Application Specification SSPC PA 1, latest revision for "Shop, Field and Maintenance Painting".
- B. Thinning shall be permitted as recommended by manufacturer for conditions of application.
- C. Coating procedures and recoat cycles are critical. It is imperative that manufacturer's recommendations be strictly followed. Any deviation from printed literature must be approved in writing by manufacturer prior to starting alternate procedures.
- D. The following surfaces shall be completely blasted and primed prior to erection: both sides of roof plates, all surfaces of rafters and girders, column caps and mating surfaces of bolted connections of roof structure. All areas of roof made inaccessible after erection shall receive the entire coating system. These surfaces shall be prepared and primed prior to erection. The underside of the floor plates shall not be blast cleaned or coated. Areas of the room seam made inaccessible after erection shall be coated on a best effort basis.
- E. At CONTRACTOR'S option, following surfaces may be either blasted and primed prior to erection, or blasted and primed after erection: interior and exterior of shell plates, interior and exterior of knuckles on knuckle roof tanks, the interior of the floor plates of the reservoir and roof supporting columns. Areas other than those specifically mentioned may be cleaned and primed prior to erection upon approval from ENGINEER. These surfaces shall be prepared and primed.
- F. Though it is the intent of this specification to properly protect all tank surfaces, it is not a requirement to perform any surface preparation, priming or coating on the underside of the reservoir floor plates.

3.06 MECHANICAL AND ELECTRICAL EQUIPMENT

- A. Refer to mechanical and electrical sections with respect to painting and finishing requirements, color coding, and identification banding of equipment, ducting, piping and conduit.
- B. Remove grilles, covers, and access panels for mechanical and electrical systems from location and paint separately.
- C. Finish paint primed equipment to color selected.

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- D. In finished areas, prime and paint insulated and bare pipes, conduits, boxes, insulated and bare ducts, hangers, brackets, collars and supports, except where items are plated or covered with prefinished coating. Color and texture to match adjacent surfaces unless otherwise directed.
- E. Replace identification markings on mechanical or electrical equipment when painted over or spattered.

3.07 CLEANING

- A. As work proceeds and upon completion, promptly remove paint where spilled, splashed, or spattered.
- B. During progress of work, keep premises free from any unnecessary accumulation of tools, equipment, surplus materials and debris.
- C. Upon completion of work, leave premises neat and clean.

3.08 COATING SYSTEMS FOR INTERIOR RESERVOIR SURFACES

- A. System No. 1 Reservoir Interior (all surfaces): Select and use epoxy or polyurethane, at CONTRACTOR'S option.

SURFACE PREP.	PAINT MATERIAL	MIN. COATS, COVER
SSPC – SP10 Near White Blast Surface Profile: 2.5 – 3.5 mils	NSF Epoxy	1 coat, 10 MDFT
	NSF Epoxy	1 coat, 10 MDFT

Or

SURFACE PREP.	PAINT MATERIAL	MIN. COATS, COVER
SSPC – SP10 Near White Blast Surface Profile: 2.5 – 3.5 mils	NSF Polyurethane	1 coat, multiple passes, 20 MDFT

1. Application Schedule:

- a. Use this system on all interior metal surfaces of the tank, including, but not limited to, steel plates and structural steel; interior and exterior surfaces of the inlet, outlet and overflow piping; manhole cover; hatches; ladders; landings; couplings and vents
- b. Provide full coating thickness to the top of all structural steel that will be covered by the roof plates, or otherwise shielded from coating thickness, before the structural steel members are installed. Remove coating in areas to be welded.
- c. Also use this system on the exposed surfaces of direct buried concrete encased steel pipe.
- d. Also use this system on all stainless steel surfaces exposed inside the tank. Interior surfaces of stainless steel pipe shall be coated a distance of 24 inches minimum where stainless steel pipe is connected to carbon steel or ductile iron pipe.

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B. System No. 5 -- Reservoir Exterior (all surfaces).

SURFACE PREP.	PAINT MATERIAL	MIN. COATS, COVER
SSPC – SP6 Surface Profile: 1.5 – 2.5 mils	Epoxy	1 coat, 3-4 MDFT
	Intermediate Epoxy	1 coat, 4-5 MDFT
	Aliphatic Polyurethane	1 coat, 3-10 MDFT

1. Application Schedule: Use this system on exposed exterior metal surfaces of the tank. For galvanized surfaces to be coated, reference System No. 10.

C. System No. 10 - Galvanized Metal Conditioning:

SURFACE PREP.	PAINT MATERIAL	MIN. COATS, COVER
Solvent Clean (SP1) Followed by Hand Tool (SP2), Power Tool (SP3), or Brush-off Blast (SP7)	Manufacturer's Recommended Primer followed by System No. 5 Finish Coats	

1. Application Schedule: Use on galvanized surfaces, including gratings before application of System No. 5.

3.09 DISINFECTION

- A. Disinfection of interior surfaces shall be performed in the presence of the OWNER'S representative in accordance with all the requirements of applicable regulatory agencies. Disinfection shall be performed after protective coatings have been applied to the interior surfaces. Prior to disinfecting, the complete interior shall be washed down with clean water and thoroughly flushed out. Disinfection shall be accomplished by the methods outlined in ADEQ Bulletin No. 8 and AWWA C652, latest edition. Chlorine solution accumulated on the bottom shall be drained to waste. Rinsing with clear water after disinfecting is not required.

3.10 BACTERIOLOGICAL AND VOC TESTING

- A. After the disinfection and hydrotesting procedures are completed and before water from the storage facility is released to the distribution system, water from the facility shall be sampled and

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tested for bacteriological and volatile organic compound (VOC) levels. These tests shall be conducted by the OWNER.

3.11 ACCEPTANCE AND WARRANTY

- A. The reservoir coating work shall be deemed acceptable when the reservoir coatings have been cured, and the reservoir disinfected and filled for water sampling, or thirty days from completion of curing and disinfection, whichever is later. The acceptance by the OWNER of the completed work as specified herein is subject to the CONTRACTOR'S warranty for the completed work against defects in materials or workmanship furnished by the CONTRACTOR for a period of one year from the date of acceptance of work. CONTRACTOR shall provide a certified diving inspector approved by the OWNER, experienced in inspecting and video recording coating systems in active potable water tanks. Inspection shall be scheduled for the 11th month of the one year warranty. Furnish OWNER a written report and copy of the video.

- END OF SECTION -

**SECTION 13208
WELDED STEEL RESERVOIR**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. The furnishing, erection, testing, and disinfection of one (1) 1,000,000-gallon welded steel water reservoir, complete in every detail, with all appurtenances, as required in the Specifications and shown on the Drawings.

1.02 RELATED SECTIONS

- A. Section 03300 - Cast-In-Place Concrete.
- B. Section 05590 - Miscellaneous Metals.
- C. Section 09900 - Paints and Coatings.

1.03 DESIGN REQUIREMENTS

- A. One (1) 1,000,000 gallon capacity welded steel reservoir meeting the following conditions:
 - 1. Diameter: 83'-0".
 - 2. Shell height: 25'-0 +".
 - 3. Overflow height: 25'-0".
- B. Design loading:
 - 1. Roof live loading: 20 psf.
 - 2. Design wind velocity: 100 mph.
 - 3. Seismic design: AWWA D100, Section 13, Seismic Zone 2B.
 - a. Soil profile: Type B.
 - b. Horizontal acceleration: 0.13 g.
 - c. Vertical acceleration: 0.1 g.
 - 4. Lowest mean ambient temperature: 40°F.
 - 5. Allowable soil bearing: 2,500 psf.

1.04 SUBMITTALS

- A. Provide list of subcontractors with bid.
- B. Provide complete design calculations and detailed drawings signed and sealed by a civil engineer licensed in State of Arizona.
- C. Submit detailed shop drawings and supplemental information including following:
 - 1. Dimensional drawings, indicating size and thickness of all members.
 - 2. Weld type and size.

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3. Accessory list with fabrication details.

D. Provide OWNER with welder qualifications.

1.05 QUALITY ASSURANCE

A. Use adequate number of skilled workers trained and experienced in necessary crafts and who are completely familiar with specified requirements and methods required for proper performance of work in this Section.

B. Tank manufacturer shall have fabricated and installed at least 10 tanks similar to those being provided for this project under similar service condition. Project location and person to contact for references shall be provided upon request by ENGINEER.

C. Manufacturer shall have at least 5 years experience in manufacture of welded steel water storage tanks or reservoirs.

D. Use equipment of adequate size, capacity, and quantity to accomplish Work in timely manner.

1.06 WARRANTY

A. Warrant reservoir against defects in materials or workmanship for a period of 1 year from date of acceptance of work.

PART 2 PRODUCTS

2.01 MATERIALS

A. Minimum material thicknesses for plates and structural members used in painted steel reservoirs shall be in accordance with AWWA D100, except minimum roof plate thickness shall be 3/16".

B. Design, fabrication and erection of welded steel reservoirs shall be in accordance with AWWA D100. Section 14 – Alternate Design Basis shall not be permitted.

C. All welding shall comply with the requirements of the AWWA D-100, Section 8.

2.02 ACCESSORIES

A. Location of accessories shall be determined per Drawings. Accessories shall be in accordance with applicable safety and building codes including C.F.R. 29 CFR191027, OSHA and UBC.

B. Roof columns: Column base plates shall not be welded to bottom plates, but shall be prevented from lateral movement by angle clips welded to the bottom plate.

C. Shell manway: Provide two (2) 30" diameter manways with stainless steel interior davit assembly and self-positioning U-shaped gaskets. Manway shall have provisions for locking.

D. Ladders:

1. Conform to applicable local, state and federal regulations.

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2. Provide carbon steel interior ladder blasted and painted same as interior with Type 316 stainless steel Saf-T-Climb assembly including removable section.
 3. Provide isolation kits as required between the connection of the steel support tabs and the stainless steel Saf-T-Climb assembly.
 4. Provide stainless steel storage brackets mounted on tank roof for removable Saf-T-Climb extension.
 5. Provide carbon steel exterior ladder blasted and painted same as exterior with a galvanized Saf-T-Climb assembly.
 6. Provide 1 safety climb belt, sleeve set and safety locking mechanism.
- E. Galvanized steel platform grating: Provide 2-1/2" x 2-1/2" x 1/4" angle to support each side of the platform grating. Platform grating to be 3' wide with grip strut deck and span distance between exterior ladder and tank shell.
- F. Roof guardrails shall comply with applicable local, state and federal regulations and AWWA D100-96. Minimum 1 1/4" diameter schedule 40 steel pipe. Roll roof handrails to radius concentric with reservoir rim.
- G. Provide one 42" square roof hatch with intrusion alarm in accordance with AWWA D100. Hinges shall be stainless steel. Provide security bar assembly. Extend curb 8" above roof plate. Hatch shall have hold open device, hasp lock and security bar. Hatch shall lap curb a minimum of 2" when closed with weather tight seal.
- H. Provide one 48" diameter mushroom type roof vent with removable lid. Vent design shall conceal screens from horizontal exposure. Vent shall be outfitted with 1/2" x 1/2" stainless steel mesh and an 8-mesh nylon insect screen held in place with stainless steel clamping system.
- I. All nuts and bolts in the roof structure system shall be type 316 stainless steel. Nuts shall be free of grease and oil.
- J. Overflow: Provide weir inlet with overflow pipe to terminate with a plain end as shown on the Drawings. Minimum thickness: 1/4" Flanges; AWWA C207.
- K. Provide other pipe connections as shown.
- L. Level indicator:
1. Quantity: 1
 2. Indicator shall be graduated in inches of liquid level.
 3. Float, float cable, guide wires, anchors, etc.: Stainless steel.
 4. Conduits and elbows: Aluminum.
 5. Manufacturer: Endress and Hauser Model 2500, or approved equal.

PART 3 EXECUTION

3.01 FABRICATION AND ERECTION OF WELDED STEEL RESERVOIRS

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- A. Fabricate and erect in accordance with provisions of AWWA D100- 96.
- B. Welding shall comply with requirements of AWWA D100, Section 8.

3.02 RADIOGRAPHY

- A. The CONTRACTOR shall have a certified welding inspector be responsible to radiograph the tank in accordance with AWWA D100-96. A complete radiography package including x-ray film and Radiographic Report shall be submitted to the OWNER.
- B. The CONTRACTOR reserves right to undertake additional radiographic testing, beyond that required by AWWA D100.
- C. The CONTRACTOR shall provide a written report of weld testing, including prints of X-rays and analysis of test plugs, if any.
- D. Any and all defects found in plates or welds shall be removed and corrected by CONTRACTOR at the CONTRACTOR'S expense.
- E. The ENGINEER reserves the right to have test plugs cut from work where and when necessary in its opinion. The cost of taking two test plugs, testing and repair of holes shall be borne by CONTRACTOR. Additional test plugs are at OWNERS expense.

3.03 VACUUM TEST

- A. After tank is completed and before it is painted, welded seams in tank bottom shall be tested in accordance with AWWA D100-96, Section 11.12.1.2.

3.04 VENTILATION AND LIGHTING

- A. Particular care shall be exercised during cleaning and painting of interior of tanks. Provide means of ejecting air from tank in order to remove dust and solvent vapors. Comply with Mohave County standards.
- B. The CONTRACTOR shall have air-moving equipment equipped with explosion proof motors at the Site adequate to remove abrasive dust and solvent fumes, to prevent injury to workers and accumulation of volatile gases, which will retard curing of paint, or create an explosive environment.
- C. During cleaning and paint spraying operations on tank interior, workers applying paint system shall be provided with proper air filter masks or fresh air masks in accordance with OSHA.
- D. Lighting shall be provided to allow proper safety, workmanship, and inspection. All interior lighting shall be explosion proof.
- E. Manholes and other tank openings shall remain open during cleaning, painting and curing operations.
- F. In addition to meeting the minimum requirements listed above, the CONTRACTOR shall be responsible for complying with all applicable regulations of the various local, state, and federal agencies.

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WELDED STEEL RESERVOIR**

3.05 TANK COATING

- A. Interior and exterior tank coatings shall be applied in accordance with Section 09900. All interior steel surfaces not accessible to applications of required protective coatings nor protected by continuous fillet welds shall be coated before assembly.
- B. Apply finish coat to top of rafter.

3.06 DISINFECTION

- A. Disinfection of the reservoir shall be performed in accordance with requirements of AWWA C652-92 or latest revision, Section 09900, and ADEQ Bulletin No.8.

3.07 FILLING AND HYDROTESTING

- A. Upon completion of protective coatings and after disinfection is satisfactorily completed, the reservoir shall be filled with water. Water required for hydrotesting will be furnished by OWNER.
- B. Once reservoir is completely filled, it shall sit for a period of 24 hours. If no leaks are present, tank has satisfactorily passed hydrotest.
- C. If repairs are required, interior and exterior coatings shall be protected during repairs, coatings shall be touched up as necessary, and tank shall be retested to satisfaction of ENGINEER and OWNER before work is accepted.

3.08 WARRANTY

- A. The reservoir shall be deemed accepted when the reservoir has been proven free from leaks and other defects to the satisfaction of the OWNER. The acceptance by the OWNER of the completed work as herein specified is subject to the CONTRACTOR'S warranty for the completed work against defects in material or workmanship furnished by the CONTRACTOR for a period of one (1) year from the date of acceptance of the work.

3.09 FINAL CLEANUP

- A. Upon completion of all work under this Contract, the CONTRACTOR shall remove from the Site any and all construction waste generated by work under this Contract. The CONTRACTOR shall remove all temporary structures and facilities and leave the Site, including access roads, in an equal or better condition than when Work was started.

3.10 PROTECTION

- A. Inlet, outlet, and drainpipe openings in tank shall be covered with strong cover to keep blasting abrasive and paint material from entering openings. The CONTRACTOR shall not start operations until openings have been properly protected and reviewed by the OWNER.

- END OF SECTION -

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**SECTION 13421
FIELD INSTRUMENTS**

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Instruments and control equipment.
- B. Impulse and signal piping including tubing, fittings, valves, and support materials.
- C. Installation of instrumentation and control equipment including field transmitters, sensing elements, control valves, analyzers, and miscellaneous devices.
- D. Control equipment as listed in Exhibit E - Instrument Index and as specified or as shown on Exhibit F - Instrument Data Sheets.

1.02 RELATED SECTIONS

- A. Section 13495 - Control System Commissioning and Start-up.
- B. Section 16001 - Electrical Work.
- C. Exhibit E - Instrument Index.
- D. Exhibit F - Instrument Data Sheets.
- E. Exhibit G - Sample Calibration Reports.

1.03 SITE CONDITIONS

- A. Indoor applications:
 - 1. Temperature: 50 to 110°F.
 - 2. Humidity: 10 to 90%.
- B. Outdoor applications:
 - 1. Temperature: 20 to 130°F.
 - 2. Humidity: 10 to 100%.
- C. Electrical power source: 120-volts ac, 60 Hz.
- D. Analog signals:
 - 1. Voltage: 24-volt dc.
 - 2. Range: 4 to 20 mA.
 - 3. Load impedance: 0 - 750 ohms, minimum.
- E. Discrete signals:
 - 1. Voltage: 24-volt dc.

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2. Contact type: Form C (1 NO, 1 NC), minimum.
3. Rating: 2 amperes at 30-volt dc, minimum.

1.04 SUBMITTALS

- A. Submitted information relating to instrumentation and control devices shall be referenced by instrument tag number, as defined in Exhibit E - Instrument Index, listed on submittal documents.
- B. Pre-construction:
 1. For review: Manufacturer's data or specification sheets for instrumentation and control devices showing design parameters, equipment catalog designations, calibration range, and clearly identifying options provided.
 2. For information only: Certified outline, installation, and wiring interconnection drawings for equipment and accessories provided. Wiring interconnection drawings shall define terminal numbers and functions for interface with other instruments and equipment.
- C. Operation and maintenance manuals, for information only:
 1. Complete instruction manuals and parts lists covering installation, operation, wiring interconnections, and maintenance of equipment. Manuals shall include interface drawings defining terminal numbers and functions for interface with other instruments or equipment.
 2. Schematic and wiring interconnection drawings for instruments wired to PLC enclosure terminals, motor control centers, and terminal panels showing all interconnections and relay-based control logic. Show color of wire, all termination points, terminal numbers, cable and wire numbers. Assign cable and wire numbers for external panel wiring. Cable and wire numbers shall be tag number oriented.
- D. Record documents, for information only:
 1. "As-built" control loop diagrams and schematic drawings as defined above.
 2. Instrumentation calibration and commissioning reports as defined in Section 13495.

1.05 SPARE PARTS

- A. Provide 1-year supply of spare parts as recommended by equipment manufacturer as part of initial installation.

PART 2 PRODUCTS

2.01 INSTRUMENTS

- A. Refer to Exhibit E - Instrument Index for device listings and estimate of installation responsibilities. Instruments referencing an Instrument Data Sheet number belong to this section. CONTRACTOR responsible for determining actual installation requirements of devices provided.
- B. Refer to Exhibit F - Instrument Data Sheets for instrument specification requirements and acceptable manufacturers.

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- C. Do not use Instruments or other devices containing nonencapsulated mercury.
- D. Instruments and control equipment shall be readily available from U.S. suppliers.
- E. Field instrumentation shall be standardized insofar as practicable.
- F. Measuring devices shall be complete with necessary condensation chambers, isolating valves, and seal pots.
- G. Bellows-type meters shall be capable of taking full line pressure on one side only, without damage or loss of calibration.
- H. Transmitter fill fluid, if used, shall be silicone, unless otherwise specified.
- I. Use diaphragm seals where corrosive or fouling liquids require process isolation from transmitter element. Seals shall be standardized insofar as practicable for interchangeability.

2.02 WIRE AND CABLE TAGS

- A. Type: Embossed, heat-shrink tubing.
- B. Color: White with black markings.

2.03 INSTRUMENT WIRING

- A. Provide No. 16 AWG single twisted shielded pair cable for 24-volt dc analog signals in accordance with Section 16001.
- B. Provide No. 16 AWG, 600-volt wire for 24-volt dc and 120-volt ac signals in accordance with Section 16001.
- C. Provide No. 12 AWG, 600-volt wire for 120-volt ac power circuits in accordance with Section 16001.

2.04 INSTRUMENT IDENTIFICATION

- A. Each instrument and control device shall have a tag permanently attached to case with following applicable information:
 - 1. Tag number.
 - 2. Manufacturer's name.
 - 3. Model number.
 - 4. Serial number.
 - 5. Operating range.
 - 6. Calibration setting/range.
 - 7. Power rating.

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- B. Each control valve and actuator shall have stainless steel nameplate, permanently fastened to valve body or actuator with following as applicable:
1. Manufacturer's name, model number, and serial number.
 2. Valve action on air failure.
 3. Operating range and bench setting.
 4. Body and trim size.
 5. Body and trim materials.
 6. Body and flange rating.
 7. Type of packing and lubricant.
 8. Flow arrow indicating direction of flow.
 9. Tag number.

PART 3 EXECUTION

3.01 INSTALLATION - GENERAL

- A. Instrument and control devices shall be installed in accordance with manufacturer's recommendations and/or where approved by OWNER'S Representative.
- B. Locate instruments and control devices where shown on Drawings and/or designated by OWNER'S Representative.
- C. Instruments shall be mounted so that they are rigidly supported, level and plumb, and in such a manner as to provide accessibility; protection from damage; isolation from heat, shock and vibration; and freedom from interference with other equipment, piping, and electrical work.
- D. Manufacturer's recommendations referred to herein shall be as stated in manufacturer's installation manual and/or by manufacturer's service representative. Final interpretation of "installation requirements" will be by OWNER'S Representative.

3.02 INSTRUMENT EQUIPMENT MOUNTING

- A. Instrumentation equipment shall be mounted to the reservoir using tank flanges, pipe mounting stands or field-fabricated mounting brackets.
- B. Instrument accessibility: Following general rules shall be adhered to, unless limited by other requirements in design of system.
1. Instrument process connections shall be located for maximum convenience in operation and servicing of instrument. Connections shall be oriented so that instruments or piping will not obstruct platforms, or ladders.
 2. Field-mounted instruments shall be installed so that they are accessible from grade, platform, or permanent ladder. Instruments requiring adjustment or inspection shall be accessible for servicing from grade, walkway, platform, or permanent ladder.

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3. Locate remote instruments and control devices (devices not located in or on process lines) at a nominal height of 4-1/2' above finished floor, grade, or platform, unless otherwise defined. Provide instrument racks for location in which three or more instruments or control devices are located within close proximity of each other.
4. Control valves shall be accessible from grade or platforms. Manufacturer recommended clearance distances shall be used.
5. Local indicators, recorders, and controllers shall be mounted so they are readable, controllable, and serviceable from grade or platforms.

3.03 WIRE AND CABLE INSTALLATION

- A. Maintain minimum of 1' separation between signals operating at voltages greater than 120-volts ac and instrumentation or communications signals. Group and route wire/cables as follows:
 1. Low-voltage/low current dc instrumentation signals (30-volts/50 mA or lower).
 2. High-voltage dc alarm signals (48-volts or greater).
 3. Low-voltage ac control signals (120-volts or lower).
 4. High-voltage ac power signals (greater than 120-volts).
 5. Communications signals.
- B. When instrumentation wiring is required within conduit, wiring shall be within metallic conduit and mounted to provide immunity from EMF noise interference.
- C. Install continuous wire from terminal-to-terminal. Splices not acceptable.
- D. Shielded signal cable:
 1. Connect shields to common ground at source of loop power.
 2. Shields of multiple cable runs shall be connected on separate terminal blocks, but not grounded.
 3. Cut and tape shield at destination end.
- E. Identify both ends of wires and/or cables with permanent white embossed, heat-shrink tubing wire markers, with black markings.

3.04 CLEANING

- A. Before assembly or erection, thoroughly clean instruments of temporary protective coatings and foreign materials.
- B. After erection of equipment, clean external surfaces of oil, grease, dirt, or other foreign material.

- END OF SECTION -

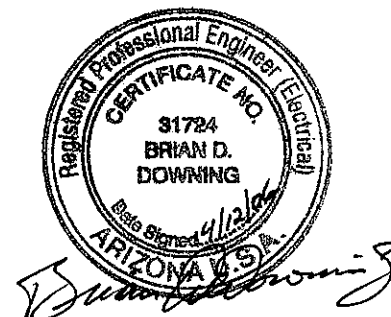
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1175.02.100 GOLDEN VALLEY RANCH RESERVOIR 2750 N-1

**ELECTRICAL AND INSTRUMENTATION
SPECIFICATIONS**

DIVISION 16

16000	GENERAL ELECTRICAL REQUIREMENTS
16111	CONDUITS
16117	CONCRETE MANHOLES, HANDHOLES AND PULL BOXES
16123	600 VOLT CLASS CABLE
16124	INSTRUMENTATION CLASS CABLE
16130	OUTLET, PULL, AND JUNCTION BOXES
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16422	METERED UNDERGROUND SERVICE PEDESTAL
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16477	600V FUSES
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DIVISION 17

17000	INSTRUMENTATION
17111	FLOAT SWITCHES
17122	LEVEL TRANSMITTERS – PRESSURE TYPE
17150	LIMIT AND POSITION SWITCHES

SECTION 16000

GENERAL ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Work and materials necessary for erecting a complete electrical and instrumentation system, tested and ready for continuous use.

B. Related Sections

1. Division 0 Bid Requirements, Contract Forms, and Contract Conditions
2. Division 1 General Requirements
3. Division 2 Site Construction
4. Division 3 Concrete
5. Division 9 Finishes
6. Division 11 Equipment
7. Division 13 Special Construction
8. Division 15 Mechanical
9. Division 17 Instrumentation

1.02 DEFINITIONS

- ###### A. The term "Provide" means "Furnish and Install".

1.03 SYSTEM DESCRIPTION

A. Design Requirements

1. If any contradictions, contrasts, or inconsistency appears, the most strict criteria noted and the collective requirements in any and all of the project documents shall apply.

1.04 SUBMITTALS

A. Intent

1. Organize work so that a complete electrical, instrumentation, and control system for the facility will be provided and will be supported by accurate shop drawings, record drawings, and O&M manuals.
2. Submit detailed shop drawings and data prepared and organized by the suppliers. Provide quantity of submittal sets in accordance with the requirements of Division 1.
3. Submittals shall be neatly grouped and organized by specification section number, and sub-section. Related information shall be highlighted, and the specific product shall be marked. All submittals shall be complete, and presented in one package.

Incomplete submittals will be returned without review. If a portion of the project requires a fast track schedule, that portion only may be submitted earlier under a separate cover letter.

4. Work performed or equipment provided without engineer approved submittals is done at contractor's risk. Cost to re-work or re-supply will be born solely by the contractor.

B. Product Data

1. A complete list of the equipment and materials, including the manufacturer's name, product specification, descriptive data, technical literature, performance charts, catalog cuts, installation instructions, and spare part recommendations for each different item of the equipment specified. The above shall clearly show all the specified requirements as described in the Specifications including but not limited to specific UL and NEMA rating, technical capabilities, test result verifications, and acceptance letters.
2. Submittals not in compliance with the specifications must include the following information:
 - a. Reason for non-compliance or variance
 - b. Calculations and drawings for redesign of related components including detail drawings showing internal and assembly details, with installation instructions.
 - c. Proposed layout showing any modifications or exceptions to related work made necessary by this work, with calculations and drawings showing such modifications or exceptions.

C. Shop Drawings

1. Drawings containing complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated and will operate as intended. Drawings shall show proposed layout, anchoring, support, and appurtenances of equipment, and equipment relationship to other parts of the work including clearances for maintenance and operations.

D. Utility Coordination

1. Submit copies of service entrance shop drawings to the utility, per utility submittal requirements, prior to submittal to the Engineer. Obtain written approval from the power utility company that the service entrance equipment is acceptable prior to release the order to the supplier for fabrication. Provide a copy of the approval letter from the utility with the submittal.

E. Closeout Submittals

1. Provide "Record Drawings" of the electrical, control, and instrumentation work to include:
 - a. Step-by-step procedure manuals for the installation, operation start-up, and maintenance of the equipment.
 - b. Installation, operating, troubleshooting, and maintenance and overhaul instructions in complete detail.

- c. Possible breakdowns and repairs, and troubleshooting guides, as well as simplified wiring and control diagrams of the system installed. This shall provide the Owner with comprehensive information on all systems and components to enable operation, service, maintenance and repair.
 - d. Exploded or other detailed views of all equipment, devices, assemblies, and accessory components shall be included, together with complete parts lists and ordering instructions.
2. Provide an "As Built" set of Plans to Owner. Maintain at all times a marked up set of Plans showing the following information:
- a. Actual installed circuit numbers, conduit sizes, cable tray routing, number of conductors, conductor sizes (larger than #12 AWG), and all other deviations from the design Plans.
 - b. Underground conduit, duct banks, and concealed items dimensioned on the Plans from permanent, visible, building features.
 - c. Actual motor size, starter size, and overload heater size, along with all other protective equipment for all 480 V and 4160 V motor circuits.
 - d. Conductor identification and panel schedules.

1.05 QUALITY ASSURANCE

A. Regulatory Requirements

1. Electrical work, including connection to electrical equipment integral with mechanical equipment, shall be performed in accordance with the latest published regulations, codes, and standards, of the following:
- a. National Electrical Code (NEC)
 - b. State and local codes
 - c. Institute of Electrical and Electronic Engineers (IEEE)
 - d. American National Standards Institute (ANSI)
 - e. American Society for Testing and Materials (ASTM)
 - f. Insulated Cable Engineers Association (ICEA)
 - g. National Electrical Manufacturers Association (NEMA) Standards
 - h. Federal Occupational Safety and Health Act (OSHA)
 - i. National Fire Protection Association (NFPA)
 - j. National Electrical Testing Association (NETA)

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Electrical panels, switchgear, motor control centers, and other electrical equipment, shall be shipped in sealed dust and moisture proof plastic sheet enclosures, and the seal maintained until units are installed. Said units shall be new and free of any dirt, dust, water, grease, rust, damaged parts or components.

1.07 PROJECT/SITE CONDITIONS

- A. Verify site conditions before bidding or performing work.

1.08 SCHEDULING

- A. Maintain a work schedule showing work to be performed, sequence of work, major milestones, and manpower loading. Coordinate schedule requirements with other trades. Provide adequate staff to perform the work in the time required by the schedule.

1.09 SYSTEM STARTUP

- A. After installation and testing of all electrical and instrumentation equipment and systems, energize all equipment and leave ready for continuous operation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers and model numbers shown on Plans or listed in the specifications are intended to establish a minimum standard of quality and acceptability.

2.02 MATERIALS

- A. Materials, equipment, and parts comprising any unit, or part thereof, specified or indicated on the Plans, shall be new and unused, of current manufacture, and of highest grade consistent with the state of the art. Damaged materials, equipment, and parts, are not considered to be new and unused, and will not be accepted.

2.03 MANUFACTURED UNITS

- A. The fabricator of major components and manufactured units, such as distribution panel boards, switchgear, and motor control centers, shall also be the manufacturer of the major devices therein.
- B. Electrical equipment provided with mechanical equipment assemblies shall be in compliance with this specification.

2.04 EQUIPMENT

- A. Minimum sizes of equipment, and electrical devices, are indicated but it is not intended to show every offset and fitting, nor every structural or mechanical difficulty that will be encountered during the installation of the work.
- B. Electrical equipment shall be capable of operating successfully at full-rated load, without failure, at an ambient air temperature of 60 degrees C, and specifically rated for the altitude indicated on the Plans. Provide air conditioning to meet the manufacturers' operating temperature for electrical equipment not rated for operation at that temperature.

- C. When applicable, the material used in the performance of the electrical work shall be listed by the Underwriters' Laboratories, Inc. (UL) for the class of service for which they are intended.
- D. Provide nameplates where indicated elsewhere in these specifications or on the Plans. Nameplates shall be black laminate with white letters and fastened to the various devices with round head stainless steel screws. Provide nameplates for each disconnecting means for service, feeder, branch, or equipment conductors, indicating its purpose.

2.05 FABRICATION

- A. Shop Assembly
 - 1. Equipment assemblies, such as Service Entrance Sections, Switchgear, Switchboards, Control and Distribution Panels, and other custom fabricated electrical enclosures shall bear a UL label as a complete assembly. The UL label on the individual components making up the assembly will not be considered sufficient to meet the present requirement. Whenever a generic UL label does not apply for the assembly, a serialized UL label shall be affixed to the assembly, and the serial number shall be submitted with the assembly record shop drawings.
 - 2. Custom fabricated electrical control panels, and enclosures, shall bear a UL label affixed by a local UL inspector.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Site Verification of Conditions
 - 1. Verify site conditions before bidding or performing work.

3.02 INSTALLATION

- A. Coordinate work with other trades and with certified vendor shop drawing submittals.
- B. Provide equipment in accordance with the manufacturers' requirements.
- C. Identify each conductor as required by the Contract Documents.
- D. Equipment Access:
 - 1. Install equipment so it is readily accessible for operation and maintenance.
 - 2. Equipment shall not be blocked or concealed.
 - 3. Do not install electrical equipment such that it interferes with normal maintenance requirements of other equipment.
- E. Equipment shall be installed plumb, square and true with the building construction, and shall be securely fastened.

- F. Outdoor wall-mounted equipment, and indoor equipment mounted on earth, or water bearing walls, shall be provided with corrosion-resistant spacers to maintain ¼-inch separation between the equipment and the wall.
- G. Arrange for the building in of equipment during structure construction. Where equipment cannot be built-in during construction, arrange for sleeves, box-outs, and other openings, as required to allow installation of equipment after structure construction is complete.
- H. Verify that equipment will fit support layouts indicated.
- I. Screen or seal all openings into outdoor equipment to prevent the entrance of rodents and insects.
- J. Equipment fabricated from aluminum shall not be imbedded in earth or concrete.
- K. Provide all necessary anchoring devices and supports.
 - 1. Use supports as detailed on the Plans and as specified.
 - 2. Supports and anchoring devices shall be rated and sized based on dimensions and weights verified from approved equipment submittals.
 - 3. Hardware shall be stainless steel.
 - 4. Do not cut, or weld to, building structural members.
 - 5. Do not mount safety switches and external equipment to other equipment enclosures, unless enclosure mounting surface is properly braced to accept mounting of external equipment.
- L. Verify exact rough-in location and dimensions for connection to electrical items furnished by others.
 - 1. Obtain shop drawings from those furnishing the equipment.
 - 2. Proceeding without proper information may require the Contractor to remove and replace work that does not meet the conditions imposed by the equipment supplied.
 - 3. Provide sleeves wherever openings are required through new concrete or masonry members. Place sleeves accurately and coordinate locations with the Engineer.
 - 4. Do not endanger the stability of any structural member by cutting, digging, chasing, or drilling and shall not, at any time, cut or alter the work without the Engineer's written consent.
 - a. Provide additional reinforcing if required.
 - b. Use proper tools and methods to cut, core drill, or make other penetrations.
 - c. Restore walls, ceilings, or floors to their original condition.
- M. Provide concrete foundations or pads required for electrical equipment as indicated or specified.
 - 1. Provide a 4-inch concrete housekeeping pad for floor mounted electrical equipment. Pour on top of the finished floor or slab. Drill existing slab and epoxy rebar to anchor housekeeping pad in place.

- N. Do not use equipment that exceeds the indicated dimensions except as approved in writing by the Engineer.
- O. Do not use equipment or arrangements of equipment that reduce required clearances or exceed the space allocation.
- P. Work indicated on the Plans is approximately to scale, but actual dimensions and detailed Plans should be followed as closely as field conditions permit. Field verification of scale dimensions on Plans is governed by field conditions. Installation of systems and equipment is subject to clarification as indicated in reviewed shop drawings and field coordination.
- Q. Discrepancies indicated on different Plans, between Plans and actual field conditions, or between Plans and Contract Documents shall be promptly brought to the attention of the Engineer for clarification, prior to purchasing and installing equipment.
- R. Adjust the alignment of equipment and conduit to accommodate architectural changes or to avoid work of other trades.
- S. Provide parts and pieces necessary to the installation of equipment, in accordance with the best practice of the trade, and in conformance with the requirements of these Contract Documents.
- T. Items not specifically mentioned in these Contract Documents, or noted on the Plans, or indicated on reviewed shop drawings, but which are obviously necessary to make a complete working installation, shall be deemed to be included herein.
- U. Lay out and install electrical work prior to placing floors and walls. Provide sleeves and openings through floors and walls, required for installation of conduits. Sleeves shall be rigidly supported and suitably packed, or sealed, to prevent ingress of wet concrete. Spacers shall be installed in order to prevent conduit movement. Dimensions indicated for electrical equipment and their installation are restrictive dimensions.
- V. Provide inserts and hangers required to support conduits and other electrical equipment. Coordinate inserts and hangers with other trades. Replace inserts, hangers, sleeves, or other mounting hardware which are improperly placed.
- W. Perform necessary saw cutting, core drilling, excavating, removal, shoring, backfilling, and other work required for the proper installation of conduits, whether inside, or outside of the buildings and structures. Use core drills to make circular holes.
- X. ELECTRICAL UTILITY
 - 1. Coordinate the electrical utility work with the electrical utility company. Note the additional submittal requirements under "SUBMITTALS – Utility Coordination" in Part 1 of this specification. Provide equipment and material required to bring electrical service to the service location in conformance with the electrical utility requirements. Provide the following for the electrical utility company's primary

(from utility power line to the utility transformer) and secondary (from utility transformer to the service) electrical lines in accordance with the electrical utility company's specifications and requirements:

- a. Conduits (verify quantity and sizes)
- b. Trenching, backfill, and compacting (verify trench size(s), backfill material, and compaction percentage requirements)
- c. Concrete pad(s) (for pad mounted transformer(s))
- d. Cable protection along the vertical drop at the utility company's pole (if pole mounted transformer(s))
- e. Other items required by the power utility company's specifications

Y. TELEPHONE SERVICE

1. Coordinate with the Telephone Company to provide telephone service as shown on the Plans. Provide trenching, conduit, and backfill for the Telephone Company's communication lines from the Telephone Company's main distribution panel to the telephone company's connection box at this project site, as required by the Telephone Company.

Z. TEMPORARY POWER

1. Provide and maintain temporary power and lighting systems needed for construction. Work shall include:
 - a. Weatherproof panel(s) for the Contractor's main breakers and distribution system.
 - b. Conduit and cable.
2. Use ground fault interrupting equipment.
3. Connections shall be watertight, with wiring done with Type SO portable cable.
4. Route and support cables to avoid mechanical damage.
5. Remove temporary power equipment and devices upon completion of construction.

AA. CORROSION PROTECTION

1. Wherever dissimilar metals, except conduit and conduit fittings, come in contact, the Contractor shall isolate these metals, as required, with neoprene washers, 9 mil polyethylene tape, or gaskets. Where fastening conduit, electro plated, or equivalent fasteners and stainless steel bolts shall be used.

3.03 REPAIR/RESTORATION

- A. Repair damage caused by construction or demolition work to restore damaged areas to original condition.
- B. Factory finishes damaged during shipping, or construction, shall be restored to original new condition. Rust shall be removed, and bare metal surfaces shall be primed and painted to match the original surrounding finish.

3.04 FIELD QUALITY CONTROL

A. Site Tests

1. The electrical work shall be free from improper grounds and from short circuits. Visually compare the conductor connections with connection diagrams. Perform individual circuit continuity checks using electrical circuit testers. Demonstrate proper operation of the energized electrical and mechanical devices. Correct any wiring deficiencies.

3.05 ADJUSTING

- #### A.
- Calibrate and set all adjustable electrical equipment including circuit breakers, motor circuit protectors, overload relays. Align photo cells and lights to achieve desired effects.

3.06 CLEANING

- #### A.
- Relays, starters, circuit breakers, switches, contacts, insulators, mechanisms, and buses shall be free of dust, dirt, oil, moisture, metal shavings, and other debris before testing and energizing equipment. Vacuum and wipe down inside and outside of electrical enclosures and control panels.

3.07 PROTECTION

- #### A.
- Once equipment is installed, it shall be protected at all times with plastic sheet covers until the area is free of dirt, dust, paint spray, water, and other trades. Provide heat to eliminate condensation.

End of Section

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SECTION 16111

CONDUITS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Furnish and install conduits as required, and as shown on the Drawings. Materials employed shall be as shown on the Drawings.

1.02 SUBMITTALS

- A. Submit product literature including manufacturer part number, model number, material, size, and specifications. Material shall not be installed until the Engineer has reviewed the submittal data.
- B. Shop Drawings shall be submitted for review and acceptance showing routing, conduit size, and number and size of wires in each conduit before installation of conduit and any related work.
- C. Proposed routing of conduits buried under floor slabs-on-grade.
- D. Identify conduit by tag number of equipment served or by circuit schedule number.
- E. Proposed routing and details of construction including conduit and rebar embedded in floor slabs, columns, etc. Identify conduit by tag number of equipment served or by circuit schedule number.
- F. Proposed location and details of construction for openings in slabs and walls for raceway runs.
- G. Refer to Section 16000 for further submittal requirements.

1.03 REFERENCES

- A. American National Standards Institute (ANSI): C80.1, Rigid Steel Conduit - Zinc-Coated.
- B. National Electric Manufacturers Association (NEMA): RN-1, Polyvinyl-Chloride (PVC) Externally Coated Galvanized Rigid Steel Conduit.
- C. Underwriters Laboratories Inc. (UL):
 - 1. 1, Flexible Metal Conduit.
 - 2. 6, Rigid Metal Conduit.
 - 3. 360, Liquid-Tight Flexible Steel Conduit.
 - 4. 467, Grounding and Bonding Equipment.

5. 514, Nonmetallic Outlet Boxes, Flush-Device Boxes and Covers.
6. 651, Schedule 40 and 80 Rigid PVC Conduit.
7. 870, Wireways, Auxiliary Gutters, and Associated Fittings.
8. 884, Underfloor Raceways and Fittings.
9. 886, Outlet Boxes and Fittings for Use in Hazardous (Classified) Locations.

PART 2 - PRODUCTS

2.01 RACEWAYS

- A. Exposed conduit in an unclassified or hazardous area shall be galvanized rigid steel (GRS) unless specifically indicated otherwise on the Drawings. Conduits in the corrosive areas shall be PVC coated GRS unless otherwise indicated. Underground and/or concrete encased conduits shall be PVC, unless otherwise indicated. All wiring, except as otherwise noted, shall be in conduit. Conduit size shall not be less than the National Electrical Code (NEC) size required for the conductors therein and shall not be smaller than 3/4-inch. No underground conduit shall be less than one inch.
- B. Condulet type fittings shall be Crouse-Hinds, Appleton, or equal with wedge nut covers. All condulets located outdoors or in wet locations shall be weathertight.
- C. In unclassified areas, flexible conduit shall be grounding type, weatherproof, corrosion resistant, and watertight.
- D. Couplings, connectors, and fittings shall be standard types specifically designed and manufactured for the purpose. They shall be installed to provide a firm mechanical assembly and electrical conductivity throughout.
- E. Expansion fittings shall be OZ type AX with jumper for exposed locations and type DX at structural expansion joints, Spring City, or equal. Conduits shall have expansion fittings in accordance with NEC.
- F. The conduits and fittings shall be supported per NEC requirements as a minimum.

2.02 GALVANIZED RIGID STEEL (GRS)

- A. Conduit and couplings shall be hot-dipped galvanized with zinc coated threads and outer coating of zinc bichromate, in accordance with ANSI C80.1 standards, as manufactured by Jones & Laughlin Steel Corporation, Allied Tube & Conduit Corporation, Triangle PWC, or equal.
- B. Steel conduit shall not be buried in earth without concrete encasement and additional corrosion protection. A half lapped rapping of 20 mil PVC based corrosion protection tape shall be used.

2.03 PVC COATED GALVANIZED RIGID STEEL (PVC-GRS)

- A. PVC coated GRS conduit shall be installed where shown on the Drawings or elsewhere specified and shall conform to NEMA RN-1 and ANSI C80.1 standards.
- B. The zinc surface of the conduit shall remain intact and undisturbed on both the inside and the outside of the conduit throughout the preparation and application processing. A Polyvinyl Chloride (PVC) coating shall be bonded to the galvanized outer surface of the conduit. The bond between the PVC coating and the conduit surface shall be greater than the tensile strength of the plastic. The thickness of the PVC coating shall be a minimum of 0.040-inch (40 mil).
- C. A loose coupling shall be furnished with each length of conduit. A PVC coating shall be bonded to the outer surface of the coupling and a PVC sleeve equal to the outside diameter of the uncoated conduit shall extend beyond both ends of the coupling approximately one pipe diameter or 1-1/2 inches, whichever is smaller. The wall thickness of the coating on the coupling and the sleeve shall be a minimum of 0.040-inch (40 mil).
- D. A PVC coating shall be bonded to the inner and outer surface of all conduit bodies and fittings and a PVC sleeve shall extend from all hubs. The wall thickness of the coating on conduit bodies and fittings and the sleeve walls shall be identical to those on couplings in length and thickness. The covers on all conduit bodies shall be coated on both sides and shall be designed to be completely interchangeable. The inside of conduit bodies shall remain undisturbed in the processing.
- E. Type 304 stainless steel screws shall be furnished and used to attach the cover to the conduit body. All coated material shall be installed and patched according to the manufacturer's recommended installation and patching instructions.
- F. Conduit straps shall be PVC coated or stainless steel.
- G. PVC coated conduit and fittings shall be as manufactured by Kor Kap Corporation, Occidental Coating Company, Rob-Roy, or equal.
- H. PVC coated flexible conduits shall be liquid and vaportight and manufactured in accordance with UL 360 standards.

2.04 RIGID NONMETALLIC - PVC

- A. Where specifically indicated on the Drawings, or elsewhere specified, conduit may be high density Schedule 40, 90 degrees C, heavy-duty PVC. The conduit shall be manufactured from virgin polyvinyl chloride compound which meets ASTM D1784, NEMA TC-2, ANSI C33.91, and UL 651 standards. Smoke emissions shall be limited to less than 6 grams per 100 grams of material tested.

- B. Where conduit concrete encasement is indicated on the Drawings, conduit supports shall be installed at five foot intervals. PVC conduit shall be manufactured by Carlon, Triangle Conduit & Cable, or equal.

2.05 INTERMEDIATE METAL CONDUIT

- A. Conduit and couplings shall be galvanized intermediate metal conduit manufactured in accordance with UL 1242 and as manufactured by Allied Tube & Conduit Corporation, Jones & Laughlin Steel Corporation, or equal.
- B. Intermediate metal conduit shall not be buried without concrete encasement. Threadless couplings and connectors shall not be used.

2.06 LIQUIDTIGHT FLEXIBLE METAL CONDUIT

- A. Liquidtight flexible metal conduit shall be liquid and vaportight, oil and ultraviolet ray resistant and manufactured in accordance with UL 360 standards. Liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, galvanized steel core with an extruded PVC jacket. The PVC jacket shall be rated for high ambient heat applications, 90 degrees Celsius.
- B. For corrosive locations, liquidtight flexible metal conduit shall be formed of a continuous, spiral wound, aluminum core with an extruded PVC jacket. The PVC jacket shall be impervious to corrosive liquids and vapors.
- C. An external bonding conductor shall be required for flexible conduit connections containing circuits rated at 60 amps or greater and for sizes 1 1/2 " or larger. Flexible conduit and connectors for 1 1/4" and smaller shall be listed for grounding.
- D. Connectors for liquidtight flexible conduit shall be galvanized, furnished with a sealing ring and locknut, and suitable for wet locations.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Conduit runs are schematic only, and shall be modified as required to suit field conditions, subject to review and acceptance by the Engineer.
- B. Conduit shall run continuously between outlets and shall be provided with junction boxes where connections are made. Couplings, connectors, and fittings shall be acceptable types designed and manufactured for the purpose, and shall provide a firm mechanical assembly, and electrical conductivity throughout.

- C. Conduit runs shall be straight and true. Elbows, offsets, and bends shall be uniform and symmetrical. Changes in direction shall be made with long radius bends, or with fittings of the conduit type.
- D. Conduit runs in buildings and structures shall be exposed except as specifically noted, or accepted by the Engineer.
- E. Conduit runs shall not interfere with the proper and safe operation of equipment, and shall not block or interfere with ingress or egress, including equipment removal hatches.
- F. Exposed conduits shall be securely fastened with clamps, or straps, intended for conduit use. All exposed conduit shall be run on the walls and ceiling only and shall be parallel to the planes of the walls or ceiling. No diagonal runs will be permitted. Flexible conduit shall be used only for short lengths required to facilitate connections between rigid conduit to motors from junction boxes, or control equipment.
- G. Conduit runs on water-bearing walls shall be supported one inch away from the wall on an accepted channel. When channel galvanizing, or other coating, is cut or otherwise damaged, it shall be field coated to original condition. No conduit shall be run in water-bearing walls, unless specifically designated otherwise.
- H. Conduit shall be thoroughly reamed to remove burrs. IMC or GRS shall be reamed during the threading process, and Rigid Nonmetallic PVC shall be reamed before applying fittings. A zinc rich cold galvanizing shall be used to restore corrosion protection on field cut threads. Bushings and lock nuts or hubs shall be used at conduit termination's. The total number of bends in any run between pull points shall not exceed 360 degrees. Junction boxes and pull boxes shall be installed at points acceptable to the Engineer. Conduit ends shall be plugged to prevent the entrance of moisture or debris during construction. All spare conduits shall be adequately capped and shall contain a suitable pull string.
- I. Joints shall be set up tight. Hangers and fastenings shall be secure, and of a type appropriate in design, and dimensions, for the particular application.
- J. Conduit runs shall be cleaned and internally sized (obstruction tested) so that no foreign objects, or obstructions remain in the conduit prior to pulling in conductors.
- K. After installation of complete conduit runs 2 inches and larger, conduits shall be snaked with a conduit cleaner equipped with a cylindrical mandrel of a diameter not less than 85 percent of the nominal diameter of the conduit. Conduits through which the mandrel will not pass shall not be used.
- L. Expansion fittings shall be installed across all expansion joints and at other locations where necessary to compensate for thermal expansion and contraction.
- M. Provide trenching, backfill, and compaction for conduits installed underground.

- N. Unless approved in advance by the Engineer, all conduits which transition from underground to aboveground will utilize galvanized rigid steel conduit for the bend from horizontal to vertical and for the extension above the ground. Factory 90 degree GRS bends shall be used. GRS bends and conduits shall be half lapped with 20 mil PVC tape in non-corrosive areas and shall be PVC coated rigid steel in corrosive areas. Tape wrapping shall extend a minimum 6 inches above top of slab or above finished grade.
- O. Liquid tight flexible metallic conduit 1-1/2 inch and larger shall be provided with grounding style bushings and shall have an external ground wire sized and installed in accordance with the NEC.

End of Section

SECTION 16117

CONCRETE MANHOLES, HANDHOLES AND PULL BOXES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawing and general provisions of the Contract, including General and Supplementary Conditions, apply to this Section.

1.02 SUMMMARY

- A. This Section includes the following:
 - 1. Concrete manholes and manhole accessories.
 - 2. Concrete handholes and handhole accessories.
 - 3. Concrete pullboxes and pullbox accessories.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 02, Site Work: Excavation and Backfilling.
 - 2. Division 03, Concrete: Reinforcement, and Cast-in-Place.
 - 3. Division 07, Thermal and Moisture Protection: Bituminous Waterproofing.
 - 4. Division 15, Mechanical: Plumbing Specialties.
 - 5. Section 16111, Conduits.
 - 6. Section 16170, Grounding.

1.03 REFERENCES

- A. American Association of State and Highway Officials:
 - 1. AASHTO H20-92, Standard Specifications for Highway Bridges, Fifteenth Edition.
- B. American Standards for Testing and Materials:
 - 1. ASTM A48-94, Gray Iron Castings.
 - 2. ASTM A153-82, Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
 - 3. ASTM A569-91, Steel, Sheet and Strip, Carbon (0.15% max), Hot-Rolled, Commercial Quality.
 - 4. ASTM C858-1983 Standard Specification for Underground Precast Concrete Utility Structures.
- C. American National Standards Institute (ANSI):
 - 1. ANSI-C2-1 997, National Electrical Safety Code.
- D. National Fire Protection Association (NFPA):
 - 1. NFPA-70-99, National Electrical Code.

1.04 SUBMITTALS

- A. General: Submit each item in this Article according to the conditions stated in General and Supplementary Conditions.
- B. Products furnished from listed manufacturers are pre-approved but still require submittal.
- C. Submit proposed substitutions for approval in accordance with General and Supplementary Conditions.
- D. Product Data for equipment specified, including the following:
 - 1. Certified technical data sheets shall include load capacities for manhole, handhole, and pull box covers.
- E. Shop Drawings: Show fabrication and installation details for underground utility structures and include the following:
 - 1. For manholes and handholes:
 - a. Duct sizes and locations of duct entries.
 - b. Reinforcement details.
 - c. Manhole cover design.
 - d. Step details.
 - e. Dimensioned locations of cable rack inserts, pulling-in irons, and sumps.
 - 2. For precast manholes, handholes and pull boxes: Shop Drawings shall be signed and sealed by a qualified professional engineer, and shall show the following:
 - a. Construction of individual segments.
 - b. Joint details.
 - c. Design calculations.
- F. Coordination Drawings, including plans and sections drawn to scale. Submit with Shop Drawings. Show layout and relationships between components and adjacent structural and mechanical elements. Show support sub-base criteria, type of support, and weight on each support. Indicate and certify field measurements.
- G. Product Certificates: For concrete and steel used in manholes, handholes, and pull boxes according to ASTM C858.

1.05 QUALITY ASSURANCE

- A. Drawing Compliance: Manholes, handholes, pull boxes, and accessories shall be designed, fabricated, and installed in compliance with the Drawings.
- B. AAHSTO Compliance: Provide manhole covers that are listed and labeled by AAHSTO for loadings specified.
- C. Coordination: Coordinate layout and installation of manholes, handholes, and pull boxes with other installations.

D. Comply with ANSI C2.

E. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver equipment as factory-fabricated modules with protective crating and covering.

B. Lift and support components with manufacturer's designated lifting or supporting points.

1.07 SEQUENCING AND SCHEDULING

A. Coordinate size and location of sub-base materials and compaction with other sections of the specification.

1.08 COORDINATION

A. Coordinate layout and installation of manholes, handholes, and pullboxes with final arrangements of other utilities and site grading, as determined in the field.

B. Coordinate elevations of ducts and duct-bank entrances into manholes and handholes with final profiles of conduits as determined by coordination with other utilities and underground obstructions. Revise locations and elevations from those indicated as required to suit field conditions and to ensure duct runs drain to manholes and handholes, and as approved by Construction Manager.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Underground Precast Concrete Utility Structures:

1. Carder Concrete Products.
2. Christy Concrete Products, Inc.
3. Elmhurst-Chicago Stone Co.
4. Riverton Concrete Products.
5. Rotondo Precast/Old Castle.
6. Utility Vault Co.
7. Wasau Concrete Co.
8. Hartford Concrete Products, Inc.
9. Heritage Concrete Pipe Co.
10. Or equal.

B. Frames, Covers, and Accessories:

1. Campbell Foundry Co.
2. East Jordan Iron Works, Inc.
3. McKinley Iron Works, Inc.

4. Neenah Foundry Co.
5. Flockhardt Foundry Co.
6. A.B. Chance Co.
7. Or equal.

2.02 PRECAST CONCRETE MANHOLES

- A. Precast Concrete: Air-entrained, 3,000 psi (25 mPa) compressive strength at 28 days.
 1. Reinforcing: AASHTO H20; bridge loading.
 2. Construction: In modular sections with tongue and groove joints.
 3. Manhole Shape: As indicated, and in accordance with ORNL standard ES-1.1-17 Type A standard electrical manhole.
 4. Inside Dimensions: As indicated.
 5. Wall Thickness: 12 in.
 6. Include 36-in. diameter grooved opening in top section.
 7. Necking and Shaft Sections: 30-in. diameter clear opening.
 8. Include 12-in. drain opening and two 1-inch ground rod openings in base section.
 9. Window for Duct Entry: As indicated.
 10. Include cable pulling irons opposite each duct entry window.
 11. Include inserts for cable racks at 2 ft. on center.
 12. Include precast manhole steps at 16 in. on center in neck and hot dip galvanized ladder inside manhole.

2.03 CAST-IN-PLACE MANHOLES

- A. Concrete: 3,000-psi compressive strength at 28 days in conformance with requirements of Division 3, with steel bar reinforcing per ORNL standard ES-1.1-17.
- B. Provide reinforcing under the provisions of Division 3.
- C. Provide two 1 inch ground rod openings in base.

2.04 MANHOLE ACCESSORIES

- A. Manhole Frames and Covers: ASTM A48; Class 30B gray cast iron, machine finished with flat bearing surfaces. Cover shall have custom design cast into exposed face similar to SNS logo with either the word "ELECTRIC" for power manholes or "COMMUNICATIONS" for communications manholes.
- B. Sump Covers: ASTM A48; Class 30B gray cast iron.
- C. Pulling Irons: 7/8-in. diameter steel bar forming a triangle of 9 in. per side when set. Galvanize to ASTM A153 for irregular shaped articles.
- D. Cable Rack Inserts: Galvanized Steel channel insert with minimum load rating of 800 lb., length to match cable rack channel.

- E. Cable Rack Channel: 2 1/4-in. X 2 1/4-in. X 1/4-in, galvanized steel channel wall bracket, 27 1/2 in. length, with 14 cable rack arm mounting holes on 1 1/2-in. centers.
- F. Cable Racks: ASTM A569; steel channel, 2 1/2 in. X 10 1/2 in. with high-glazed, wet-process porcelain insulators.
- G. Manhole Steps: Cast iron, suitable for manhole shape and construction.

2.05 PRECAST CONCRETE HANDHOLES

- A. Precast Concrete: Air-entrained, 3,000 psi (35 mPa) compressive strength at 28 days.
- B. Reinforcing: AASHTO H20; bridge loading.
- C. Construction: In modular sections with tongue and groove joints.
- D. Dimensions: Minimum inside dimensions of 48 in. width X 66 in length X 54 in. depth.
- E. Wall Thickness: 5 in.
- F. Include 12-in. sump in base section.
- G. Windows for Duct Entry: 4 duct terminators in each end and 2 duct terminators in each side, located as shown on Drawings.
- H. Knockouts: 1-10 in. X 26 in. knockout in each end, and 1-6 in. X 24 in. knockout in each side, located as shown on Drawings.
- I. Include cable pulling irons opposite each duct entry window.

2.06 HANDHOLE ACCESSORIES

- A. Handhole Frames and Covers: steel angle cast-in-place frame, machine finished with flat bearing surfaces. AASHTO H20; bridge loading. Galvanized checker plate steel cover with formed galvanized steel beams, torsion springs and safety bars, cover shall have either the word "ELECTRIC" for power manholes or "COMMUNICATIONS" for communications handholes engraved in steel name plate on frame.
- B. Pulling Irons: 7/8-in. diameter steel bar forming a triangle of 9 in. per side when set. Galvanize to ASTM A153 for irregular shaped articles.

2.07 PRECAST CONCRETE PULLBOXES

- A. The pull boxes shall be designed for traffic conditions, and the pull box and cover shall be designed for heavy traffic bridge loading unless otherwise noted.
- B. The pull boxes shall be Quikset, Utility Vault Co., or equal, with covers. The covers shall be engraved "ELECTRICAL".

- C. Precast Concrete: Air-entrained, 3,000 psi (25 mPa) compressive strength at 28 days.
- D. Reinforcing: AASHTO H20; bridge loading.
- E. Dimensions: The pull boxes shall have minimum inside dimensions of 10 1/2 in. width X 17 1/4 in length X 12 in. depth or as indicated on the drawings.
- F. Wall Thickness: minimum 7/8 in.
- G. Window for Duct Entry: 2 - 3" knockouts on each side and 1 - 3" knockout on each end.

2.08 PULLBOX ACCESSORIES

- A. Covers: reinforced concrete, air-entrained, 3,000 psi (25 mPa) compressive strength at 28 days, AASHTO H20; bridge loading.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Excavate, install base material, and compact base material under provisions of Division 2.

3.02 EXAMINATION

- A. Examine sitework, duct bank installation subbase placement, levelness, and compactness before placing the manhole sections, handholes, or pullboxes.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.03 INSTALLATION - PRECAST CONCRETE MANHOLES

- A. Install and seal precast sections according to manufacturer's instructions.
- B. Use precast neck and shaft sections to bring manhole entrance to proper elevation.
- C. Install manholes plumb.
- D. Set top of each manhole to finished elevation indicated.

3.04 INSTALLATION - CAST-IN-PLACE CONCRETE MANHOLES

- A. Form cast-in-place manholes, inside and outside surfaces, according to provisions of Division 3.
- B. Manhole configuration, inside dimensions, wall thicknesses concrete reinforcing, and duct bank window sizes and locations: According to details.

- C. Include 12-in. drain opening and two 1-in. ground rod openings in base section.
- D. Cast cable pulling irons in place opposite each duct entry window.
- E. Cast inserts for cable racks in place at 2 ft. centers.
- F. Cast manhole steps in place on 16-in. centers.

3.05 INSTALLATION - MANHOLE ACCESSORIES

- A. Install drains in manholes where shown on the drawings, and connect to daylight at the nearest location. Install ground rod with top protruding 4 in. above manhole floor.
- B. Waterproof exterior surfaces, joints, and interruptions of manholes after concrete has cured 28 days minimum, in accordance with provisions of Division 7.
- C. Attach cable racks to inserts after manhole installation is complete.
- D. Install manhole covers.
- E. Ground cable racks to manhole ground rod with #6 bare, solid copper conductor by exothermic weld process.
- F. Bring exterior #4/0 bare copper cable into manhole and connect to ground rod in manhole floor.
- G. Ground circuit #4/0 copper cable in 5" conduit to exterior cable in duct bank and manhole ground rod.

3.06 INSTALLATION - PRECAST CONCRETE HANDHOLES AND PULLBOXES

- A. Install and seal precast sections according to manufacturer's instructions.
- B. Install handholes and pullboxes plumb.
- C. Handholes and pull boxes shall be installed on 12 inches of compacted gravel and shall be installed in such a manner that the cover of the pull box will be flush with finished grade.

3.07 FIELD QUALITY CONTROL

- A. Verify that installed manholes, handholes, and pullboxes are installed plumb and level and that covers will be flush with final paved surfaces.
- B. Check that accessories are installed according to specifications and drawings.
- C. Inspect drain lines to verify proper drainage.

3.08 ADJUSTING

- A. Adjust final manhole, handhole, and pullbox frame elevations to match that of final paving or grade.

3.09 CLEANING

- A. Clean inside of manholes, handholes, and pullboxes from all construction debris and verify proper operation of drains (for both precast and cast-in-place manholes).

3.10 PROTECTION

- A. Protect, handhole, and pullbox interiors from entrance of construction debris after final cleaning is complete.

End of Section

SECTION 16123

600 VOLT CLASS CABLE

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the furnishing and installation of 600 Volt Class cables and conductors, terminations and splicing, and pulling lubricants.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.03 REFERENCES

- A. Insulated Cable Engineers Association/National Electrical Manufacturers Association (ICEA/NEMA):
 - 1. S-68-516/WC 8, ethylene-propylene rubber-insulated wire and cable for the transmission and distribution of electrical energy.
 - 2. S-61-402/WC 5, thermoplastic-insulated wire and cable for the transmission and distribution of electrical energy.
 - 3. S-66-524/WC 7, cross-linked thermosetting-polyethylene-insulated wire and cable for transmission and distribution of electrical energy.
- B. Underwriters Laboratory, Inc.
 - 1. 44, rubber insulated wires and cables.
 - 2. 83, thermoplastic-insulated wires and cables.
 - 3. 486A, wire connectors and soldering lugs for use with copper conductors.
 - 4. 486B, wire connectors for use with aluminum conductors.
 - 5. 510, insulating tape.
- C. National Electric Code

PART 2 - PRODUCTS

2.01 ACCEPTED MANUFACTURERS

- A. Conductors and Multi Conductor Cables (MCC), subject to compliance with Contract Documents, the following manufacturers are acceptable: American Insulated Wire Corporation, Cablec Corporation, Okonite Company, Southwire Company, or equal.

2.02 CONDUCTORS

- A. Wire sizes shall be American Wire Gauge (AWG) sizes with Class B stranded construction. Number 2 AWG and smaller shall be factory color coded with a separate color for each phase and neutral, which shall be used consistently throughout the system. Larger cables shall be coded by the use of colored tape. Conductors sized # 1 and larger shall be Type 2, rated for 90 degrees C. All circuit conductors, #6 or smaller shall be "THWN" stranded copper. All other conductors shall be "XHHW-2" stranded copper.
- B. Individual or multiple conductor cables for power, control, and alarm circuits of 480 volts or less shall be insulated for not less than 600 volts and shall have insulation type as indicated on the Drawings. "THHW" shall conform to ICEA S-61-402/NEMA WC 5 and UL 83 and "XHHW" shall conform to ICEA S-66-524/NEMA WC 7 and UL 44. Where wire size is not indicated, they shall be of the size required by the NEC, except that no wire external to panels and motor control centers shall be less than No. 12 AWG, unless specifically noted on the Drawings. Panel control wiring shall not be less than No. 14 AWG.
- C. All wiring shall be as indicated on the Drawings. Wires shall be new and shall be soft drawn copper with not less than 97 percent conductivity. The wire and cable shall have size, grade of insulation, voltage, and manufacturer's name permanently marked on the outer covering at not more than 2-foot intervals. All wires shall conform to the latest Standards of the ASTM, and ICEA, and shall be tested for their full length by these Standards. Insulation thickness shall be not less than that specified by the National Electrical Code.
- D. Power conductors for lighting and receptacles only may utilize "THWN" solid conductors.

2.03 TERMINATIONS AND SPLICES

- A. Cable shall be rated 600 volts. Other parts of cable systems such as splices and terminations shall be rated at not less than 600 volts. Splicing shall join conductors mechanically and electrically to provide a complete circuit prior to installation of insulation.
- B. Splices in wires No. 10 AWG and smaller shall be made with an insulated, solderless, pressure type connector, Type I, Class 1, Grade B, Style G, or Type II, Class 1 of FS W-S-610 and conforming to the applicable requirements of UL 486A.
- C. Splices in wires No. 8 AWG and larger shall be made with non-insulated, solderless, pressure type connector, Type II, Class 2 of FS W-S-610, conforming to the applicable requirements of UL 486A and UL 486B. They shall then be covered with an insulation and jacket material equivalent to the conductor insulation and jacket.
- D. Insulated conductor splices below grade or in wet locations shall be sealed type conforming to ANSI C119.1 or shall be waterproofed by a sealant-filled, thick wall, heat

shrinkable, thermosetting tubing or by pouring a thermosetting resin into a mold that surrounds the joined conductors.

- E. Bare conductor splices in wet locations or below grade shall be of the exothermic type.

2.04 PULLING LUBRICANT

- A. All cables shall be properly coated with pulling compound such as ClearGluid, Aqua Gel, Polywater, or equal before being pulled into conduits so as to prevent mechanical damage to the cables during installation. "Yellow 77" is not acceptable.
- B. Other lubricants to be substituted must be accompanied by a statement from the cable manufacturer as to its acceptable use with the cable being installed.

2.05 IDENTIFICATION

- A. All conductors shall be numbered with "tube sleeve" type tags with heat impressed letters and numbers.
- B. Color code all wiring as follows:
1. Lighting and power wiring:

CONDUCTOR	<u>120/208 VAC</u>	<u>480VAC</u>	<u>24V DC</u>	120 VAC Control/ POWER
Phase 1	Black	Brown	Blue	Red
Phase 2	Red	Orange	(-) Blue w/ white stripe	
Phase 3	Blue	Yellow		
Neutrals	White	White or Gray		White

2. Color code ends of feeder phase conductors only.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The pulling tension and side-wall pressures, as recommended by the cable manufacturer, shall not be exceeded.
- B. As far as practical, all circuits shall be continuous from origin to termination without splices in intermediate pull boxes. Sufficient slack shall be left at the termination to make proper connections. In no case shall a splice be pulled into the conduit. Conductor splicing shall not be permitted without the Engineer's approval.
- C. Install all cables in conduit.

- D. Each feeder and branch circuit shall be installed in its own individual conduit unless combining feeder and branch circuits is permitted as defined in the following:
 - 1. As specifically indicated on the Drawings.
 - 2. For lighting, multiple branch circuits may be installed in a conduit as allowed by the NEC and with the wire ampacity derated in accordance with the requirements of the NEC. Conduit fill shall not exceed the limits established by the NEC.
 - 3. When field conditions dictate and written permission is obtained from the Engineer.
- E. Feeder and branch circuits shall be isolated from each other and from all instrumentation and control circuits.
- F. Control circuits shall be isolated from all other feeder, branch and instrumentation circuits, except as noted below.
 - 1. 12 V DC, 24 V DC and 48 V DC control circuits may be combined in common conduit.
 - 2. 125 V DC control circuits shall be isolated from all other DC and AC control circuits.
 - 3. 120 V AC control circuits shall be isolated from all DC control circuits.
- G. Make splices only at pull or junction boxes.
 - 1. Crimp or indented-type connectors are not allowed, except for control circuits landed on terminal strips.

3.02 TESTING

- A. In accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End of Section

SECTION 16124

INSTRUMENTATION CLASS CABLE

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers cable use for process signal and controls.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with Contract Documents, the instrumentation cable shall be as manufactured by Belden, Okonite, or equal.

2.02 INSTRUMENTATION CABLE

- A. Instrument cable shall be Type TC, and have the number of individually shielded twisted pairs indicated on the Drawings and shall be insulated for not less than 600 volts. Unless otherwise indicated, conductor size shall be No. 18 AWG minimum. Shielded, grounded instrumentation cable shall be used for all analog signals.
- B. The jacket shall be flame retardant with 90 degrees C temperature rating. The cable shield shall be a minimum of 2.3 mil aluminum or copper tape overlapped to provide 100 percent coverage and a tinned copper drain wire.
- C. The conductors shall be bare soft annealed copper, Class B, 7 strand minimum concentric lay with 15 mils nominal thickness, nylon jacket, 4 mil nominal thickness, 90 degrees C temperature rating. One conductor within each pair shall be numerically identified.
- D. Pairs shall be assembled with a nominal 2-inch lay and shall then be group shielded with a minimum of 1.3 mil aluminum or copper tape overlapped to provide 100 percent coverage. All group shields shall be completely isolated from each other.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Feeder and branch circuits shall be isolated from each other, and from instrumentation and control circuits. Instrumentation cables shall be installed in separate raceways from other cables and wiring. This includes portions running through manholes. Instrumentation cable shall be continuous between instruments or between field devices and instrument enclosures. There shall be no intermediate splices or terminal boards, unless otherwise shown on the Drawings.
- B. Maintain electrical continuity of the shield when splicing twisted shielded pair conductors. Drain wires shall be terminated inside enclosures at grounded terminal blocks. Only one end of each instrument loop cable drain wire shall be grounded. Ground drain wire of shielded conductors at one end only.
- C. Terminate instrumentation and control wiring, including spare wires, at control panels and motor control centers on terminal boards mounted inside the equipment.
 - 1. Contractor shall supply terminal boards as required.
 - 2. Do not field wire directly to devices.

End of Section

SECTION 16130

OUTLET, PULL, AND JUNCTION BOXES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Outlet, pull and junction boxes.
- B. Related Sections include but are not necessarily limited to:
 - Division 0 - Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - Division 1 - General Requirements.
 - Section 16000 - Electrical: Basic Requirements.
 - Section 16111 - Conduits.
 - Section 16141 - Wiring Devices.
 - Section 16170 - Grounding.

1.02 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. Refer to Section 16000.

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Refer to the Contract Documents and Section 16000.

1.04 DELIVERY, STORAGE, AND HANDLING

- A. See Section 16000.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Galvanized steel boxes:
 - a. Appleton Electric Co.
 - b. Steel City.
 - c. Raco.
 - 2. Sheet metal boxes for non-classified areas:
 - a. Hoffman Engineering Co.
 - 3. Corrosion-resistant boxes:

- a. Hoffman Engineering Co.
- b. Crouse-Hinds.
- 4. Hazardous location boxes (Class I, II & III):
 - a. Appleton Electric Co.
 - b. Crouse-Hinds.
 - c. Killark.
 - d. O-Z/Gedney.
- 5. Raintight and watertight boxes:
 - a. Appleton Electric Co.
 - b. Crouse-Hinds.
- 6. Terminal boxes:
 - a. Hoffman Engineering Co.
- 7. Boxes in sidewalk:
 - a. Appleton Electric Co.
 - b. Crouse-Hinds.
 - c. O-Z/Gedney.
- 8. Boxes in earth:
 - a. Carlon Electric Products.
- 9. Exposed switch and receptacle boxes:
 - a. Appleton Electric Co.
 - b. Crouse-Hinds.
 - c. Killark.

B. Submit requests for substitution in accordance with Specification Section 01630.

2.02 MATERIALS

- A. Pull and Junction Boxes for Offices and other Dry Architecturally Finished Areas:
 - 1. Material: 14 GA, galvanized steel.
 - 2. Concentric knockouts on all four sides.
 - 3. Flat cover fastened with screws.
 - 4. NEMA 1 classification.
 - 5. UL listed.
- B. Pull and Junction Boxes for General Use Unclassified Areas Suitable for NEMA 12 Enclosures:
 - 1. Material: 14 GA galvanized steel with seams continuously welded, ground smooth and no knockouts.
 - 2. Zinc rich coating on all seams.
 - 3. Stainless steel captivated cover screws threaded into sealed wells.
 - 4. Flat door with oil resistant gasket.
 - 5. NEMA 12 classification.
 - 6. UL listed.
- C. Pull and Junction Boxes for Wet Areas:
 - 1. Material: 14 GA steel with polyester powder coating inside and out over phosphatized surfaces.

2. Seams continuously welded, ground smooth, no knockouts.
 3. Stainless steel clamps on four sides.
 4. Flat cover with oil resistant gasket.
 5. NEMA 4 classification.
 6. UL listed.
- D. Pull and Junction Boxes for Corrosive Areas:
1. Material: 14 GA steel with powdered epoxy resin coating inside and out or fiberglass-reinforced polyester material.
 2. Steel boxes:
 - a. Seams continuously welded, ground smooth, no knockouts.
 - b. Rolled lip around all sides.
 - c. Hinged door.
 - d. Captivated stainless steel door screws.
 - e. Flat door with oil-resistant gasket.
 3. Fiberglass-reinforced polyester boxes:
 - a. Hinged door with latch and lockout.
 - b. Neoprene door gasket.
 - c. Grounding bushing(s).
 4. NEMA 4X classification.
 5. UL listed.
- E. Pull and Junction Boxes for Hazardous Areas:
1. Material: Cast gray iron alloy or copper-free cast aluminum.
 2. Drilled and tapped openings or tapered threaded hub equipped.
 3. Flat bolted-down or threaded cover with neoprene gasket.
 4. Stainless steel hex head screws.
 5. Explosion proof, UL listed for Class 1 Groups C and D.
- F. Pull and Junction Boxes for Sidewalks:
1. Cast-iron box and cover, hot-dip galvanized.
 2. Flange for flush mounting.
 3. Checkered cover with neoprene gasket, pry bar slots and stainless steel screws.
 4. UL listed.
 5. Drilled and tapped holes.
 6. Watertight NEMA 4 classification.
- G. Large Pull and Junction Boxes (100 CU IN and larger):
1. Located in offices and other dry architecturally finished areas where EMT is utilized:
 - a. NEMA 1 gasketed without knockouts.
 2. Located in general use areas:
 - a. NEMA 12 construction:
 - 1) Welded steel.
 - 2) Furnished with gray enamel inside and out over phosphatized surfaces.
 3. Located in wet and corrosive areas:
 - a. NEMA 4X with stainless steel screws.

- b. Type 304 L welded stainless steel:
- 4. Constructed of 14 GA steel with seams continuously welded, ground smooth, no knockouts.
- 5. Rolled lip around all sides.
- 6. Rigid handles for covers larger than 9 SF or heavier than 25 LBS.
- 7. Split covers when heavier than 25 LBS.
- H. Terminal Boxes:
 - 1. Galvanized 16 GA steel box provided with plain blank screw cover, subpanel, and terminal points.
 - 2. Refer to Drawing for dimensions and number of terminals.
- I. Fiberglass Cable-Pulling Enclosure:
 - 1. Use: Access points to facilitate pulling of electrical cables in buried conduit runs.
 - 2. Size and quantity: As shown on Drawings.
 - 3. Type: Rectangular fiberglass composite, suitable for direct burial pedestrian traffic on top, -50 DegF, chemical, sunlight, and weather resistant.
 - 4. Provide matching top with "ELECTRIC" logo.
- J. Outlet Boxes:
 - 1. Use: Installation of wiring devices.
 - 2. Boxes for exposed wiring:
 - a. Cadmium plated, cast, ferrous metal, with threaded hubs.
 - 3. Boxes for concealed wiring:
 - a. Code gage, hot-dip galvanized steel.
 - b. Include bar hangers for metal stud partitions.
 - c. Provide barriers between switches in boxes with 277 V switches on opposite phases.
 - d. Use extension and plaster rings where required.
 - e. Provide grounding screw.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Use locknut and bushing for boxes in non-classified areas.
- B. Use cast metal boxes with threaded conduit hubs in hazardous areas.
- C. Use Type FS and FD boxes in wet areas and where exposed rigid steel conduit is required.
- D. Fill unused punched-out, tapped, or threaded hub openings with insert plugs.
- E. Use outlet boxes sized to accommodate quantity of conductors enclosed.
- F. Use boxes sized to accommodate conduit tying into box.

- G. Install pull boxes or junction boxes in conduit runs where indicated or required to facilitate pulling of wires or making connections.
 - 1. Make covers of boxes accessible.
- H. Install pull boxes or junction boxes rated for the area classification.
- I. Install rigid conduit squarely into boxes which do not have hubs or are drilled and tapped.
 - 1. Install with locknut on the outside and bushing on inside.
- J. Install conduit into boxes with hubs, or that are tapped, using thread lubricant.
- K. Do not use back-to-back boxes on this Project.
- L. Seal all points of conduit entry into fiberglass cable-pulling enclosures for a waterproof installation.
- M. Support outlet boxes for incandescent fixtures and other ceiling-mounted devices in lay-in acoustical tile ceilings by bar hangers anchored to ceiling construction members which do not interfere with tile removal.

End Of Section

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SECTION 16141

WIRING DEVICES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Light switches, receptacles, device plates, dimmers, plug-in strips and tele-power poles.
- B. Related Sections include but are not necessarily limited to:
 - Division 0 -Bidding Requirements, Contract Forms, and Conditions of the Contract.
 - Division 1 - General Requirements.
 - Section 16000 - Electrical: Basic Requirements.
 - Section 16130 -Outlet, Pull, and Junction Boxes.
 - Section 16170 - Grounding.

1.02 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. Refer to Section 16000.

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Refer to the Contract Documents and Section 16000.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
 - 1. Light switches (except explosion proof):
 - a. Hubbell.
 - b. Slater.
 - c. P&S.
 - d. Arrow Hart.
 - e. General Electric.
 - f. Leviton.
 - 2. Explosion proof light switches:
 - a. Crouse-Hinds.
 - b. Appleton Electric Co.
 - c. Killark.

3. Door switches:
 - a. General Electric.
 - b. Slater.
 - c. P&S.
 - d. Arrow Hart.
 - e. Micro-switch.
4. Receptacles (except explosion proof):
 - a. Hubbell.
 - b. Slater.
 - c. P&S.
 - d. Arrow Hart.
 - e. General Electric.
 - f. Leviton.
5. Explosion proof receptacles:
 - a. Crouse-Hinds.
 - b. Appleton Electric Co.
 - c. Killark.
6. Welding receptacles:
 - a. Crouse-Hinds.
 - b. Appleton Electric Co.
7. Tele-power poles:
 - a. Wiremold.
 - b. Walker.
8. Dimmers:
 - a. Lutron.
 - b. General Electric.
 - c. P&S.
9. Plug-in strip:
 - a. Wiremold.
 - b. Walker.

B. Submit requests for substitution in accordance with Specification Section 01630.

2.02 MATERIALS

A. Light Switches for Unclassified Areas:

1. Toggle type, quiet action, specification grade with grounding terminal.
2. Back and side wired.
3. Solid silver cadmium oxide contacts.
4. One-piece switch arm rated 20 A, 120/277 V AC.
5. UL listed.
6. Color: Ivory.
7. Wall plate: Type 304 stainless steel.
8. Type: As indicated on Drawings.

B. Receptacles for Unclassified Areas:

1. Straight blade, grounding type, specification grade.

2. Back and side wired with wrap-around bridge.
 3. Rated 20 A, 125 V AC.
 4. UL listed.
 5. Color:
 - a. For use on normal power: Ivory.
 - b. For use on UPS systems: Red.
 - c. For use on isolated ground systems: Orange.
 6. Wall plate: Type 304 stainless steel.
 7. Type: As indicated on Drawings.
- C. Light Switches for Wet Areas:
1. Pressswitch type, quiet action, specification grade, with grounding terminal.
 2. Back and side wired.
 3. Solid silver cadmium oxide contacts.
 4. One-piece switch arm rated 20 A, 120/277 V AC.
 5. UL listed.
 6. Color: Ivory.
 7. Wall plate: Gray weatherproof pressswitch type.
 8. Type: As indicated on Drawings.
- D. Receptacles for Wet Areas:
1. Straight blade, grounding type, specification grade.
 2. Back and side wired with wrap around bridge.
 3. Rated 20 A, 125 V AC.
 4. UL listed.
 5. Color: Ivory.
 6. Wall plate: Weatherproof, cast aluminum, UL listed, WDL open and closed.
 7. Type: As indicated on Drawings.
- E. Ground Fault Circuit Interrupter Receptacles:
1. Straight blade, grounding type, specification grade.
 2. Rated 20 A, 125 V AC.
 3. UL listed.
 4. Test and reset buttons.
 5. Wall plate: Indoor or weatherproof as required.
 6. Feed-through type.
- F. Light Switches for Corrosive Areas:
1. Corrosion-resistant NEMA 4X enclosure with switch consisting of:
 - a. Fiberglass reinforced polyester enclosure.
 - b. Fiberglass reinforced polyester gasketed wall plate with built-in toggle lever switch with stainless steel shaft.
 - c. Grounding bushing.
 - d. Rated 20 A, 125 V AC.
 - e. UL listed.
 - f. Type: As indicated on Drawings.
 - g. Color: Yellow.

2. Optional: Corrosion-resistant enclosure and switch consisting of:
 - a. Cast copper-free aluminum "FS" or "FD" ridge type hub box.
 - b. Toggle type, quiet action, specification grade with grounding terminal.
 - c. Rated 20 A, 125 V AC with solid silver cadmium oxide contacts.
 - d. UL listed.
 - e. Neoprene gasket.
 - f. Cast aluminum cover with stainless steel screws and lever to activate switch.
 - g. Type: As indicated on Drawings.
 - h. Color: Yellow.
- G. Receptacles for Corrosive Areas:
 1. Corrosion-resistant straight blade, grounding type, specification grade.
 2. Back and side wired with wrap-around bridge.
 3. Rated 20 A, 125 V AC.
 4. UL listed.
 5. Color: Yellow.
 6. Box: "FS" or "FD" ridge type cast hub box of copper-free aluminum.
 7. Gasket: Neoprene.
 8. Wall plate: Weatherproof, cast aluminum, UL listed, WDL open or closed.
 9. Type: As indicated on Drawings.
- H. Explosion proof Light Switches for Use in Hazardous Areas:
 1. Explosion proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2 areas, Groups E, F, and G.
 2. EDS factory sealed.
 3. Malleable iron body and cover.
 4. Aluminum sealing chamber.
 5. Front operated handle with stainless steel shaft.
 6. Rated 20 A, 125 V AC.
 7. With grounding screw.
 8. Type: As indicated on Drawings.
- I. Explosion proof Receptacles for Use in Hazardous Areas:
 1. Explosion-proof, UL listed for Class I, Division 1 and 2, Groups B, C, and D; and Class II, Division 1 and 2, Groups F and G.
 2. Factory-sealed malleable iron receptacle with spring-loaded cover.
 3. Malleable iron mounting box.
 4. Rated 20 A, 125 V AC.
 5. "Dead-front" construction requiring plug to be inserted and rotated to activate receptacle.
 6. Type: As indicated on Drawings.
- J. Welding Receptacles:
 1. 60 A, 480 V, 3 pole, 4 wire, grounding type.
- K. Plug-In Strip: Surface steel raceway plug-in strip with single 15 A, 125 V, 3 wire grounding-type receptacles spaced 18 IN on center.

1. Prewired with two #12 TW and one #12 TW green insulated ground.
2. Minimum 1-1/4 IN wide x 3/4 IN deep.
3. Suitable fittings and snap-in cover.
4. Finish:
 - a. Stainless steel.
5. Receptacle color:
 - a. For use on normal power: Ivory.
 - b. For use on UPS systems: Red.
 - c. For use on isolated ground systems: Orange.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Mount devices where indicated on the Drawings and as scheduled in Section 16010.
- B. Surface mount receptacles and light switches in concrete construction.
- C. In masonry and metal stud construction, recess mount receptacles and light switches unless device precludes recessed mounting or unless otherwise noted on the Drawings.
- D. Where more than one receptacle is installed in a room, they shall be symmetrically arranged.
- E. Set switches and receptacles plumb and vertical to the floor.
- F. Set recess-mounted switches and receptacles flush with face of walls.
- G. Do not connect dimmers to loads in excess of 80 percent of the rating of the dimmer.
- H. Provide blank plates for empty outlets.

End Of Section

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SECTION 16143

TERMINAL BLOCKS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers terminal blocks for control and other wiring.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.03 MANUFACTURERS

- A. Terminal blocks shall be Allen Bradley, Entrelec, Phoenix Contact, Allen-Bradley, or equal.
- B. Surge protection blocks shall be MTL, Phoenix Contact, Termatrab, or equal.
- C. Power distribution blocks shall be Gould, Allen-Bradley Corporation, or equal.

PART 2 - PRODUCTS

2.01 TERMINAL BLOCKS

- A. Terminal blocks shall mount on standard DIN rail, and be of the size required for conductors therein. A minimum of 25 percent spares shall be provided in each terminal box. No more than 2 conductors shall be allowed per termination. Jumper bar assemblies shall be installed for interconnecting terminal blocks, distributing power and signal commons. Terminal blocks shall be U.L. rated for 600 Volts, and 30 Amps, minimum.
- B. Grounding terminal blocks shall be provided for instrumentation cable shields. The terminal blocks shall have distinctive 2-color bodies, and shall be mounted to the DIN rail with metal screw down type clamps, providing a positive ground connection. One grounding terminal block shall be installed for every 2 instrument cables terminated. Grounding terminal blocks shall be U.L. rated for 600 Volts, and 20 Amps, minimum.
- C. Terminal blocks shall be available in a variety of colors, including red, green, blue, gray, black, yellow, and orange.
- D. DIN mount fuse holders shall have blown fuse indicators for DC and AC circuits. Fuse holders shall be of the compression clamp type. Fuse holders shall be U.L. listed, and

rated for 600 Volts. Fuse sizes shall not exceed the U.L. current rating for the fuse holders.

- E. DIN rail shall be prepunched, zinc bichromate plated steel. Symmetrical DIN rail shall be 35mmX7.5mm, minimum.
- F. Terminal blocks for 4 to 20 milliamp signals shall have knife disconnect switches, and accessible test points for testing and measurement of current loop signals, without the need for removing wire terminations.

2.02 SURGE PROTECTION BLOCKS (SPB)

- A. Analog inputs and outputs shall be terminated at surge protection blocks (SPB). The SPBs shall be designed for a working voltage of 32 volts, and shall be fused.
- B. SPBs shall provide full hybrid line to line protection, and shall have a GDT rating of 10,000 A (8/20 μ s pulse waveform).
- C. SPBs shall be UL94 V-2 listed.

2.03 POWER DISTRIBUTION BLOCKS (PDB)

- A. PDBs shall be Electro-tin plated and manufactured from high strength 6061-T6 aluminum alloy.
- B. PDBs shall be UL Recognized rated 90° C and CSA Certified.
- C. PDBs shall provide flexibility in using the connector as an in line splice or to reduce conductor size.
- D. PDBs shall be rated for 600 Volts and dual rated for Copper and Aluminum Conductor.
- E. PDBs shall have the sizes and ratings as shown on the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Each terminal block and fuse holder shall be identified with the circuit number, or conductor number, corresponding to the identification appearing on the shop Drawings for the equipment, or system.
- B. Terminal block and fuse holder markers shall be computer printed plastic-type, with permanent markings.
- C. End clamps and end sections shall be installed on each terminal block and fuse holder assembly.

D. Terminal blocks for DC voltages shall be blue, and AC voltages shall be gray.

End of Section

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SECTION 16160

ENCLOSURES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This specification includes enclosures to house electrical controls, instruments, terminal blocks, and serve as junction boxes where shown on the Drawings.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.03 MANUFACTURERS

- A. Enclosures shall be manufactured by Hammond, Hoffman, Rittal, or equal.

PART 2 - PRODUCTS

2.01 STEEL

- A. Enclosures shall be fabricated from 14 gauge steel with seams that are continuously welded. Doors shall have full length piano hinges with the door removable by pulling the hinge pin.
- B. A rolled lip shall be provided around three sides of the door and around all sides of the enclosure opening. The gasket shall be attached with oil-resistant adhesive and held in place with steel retaining strips. Exterior hardware, such as clamps, screws, and hinge pins, shall be of stainless steel for outdoor installations. A hasp and staple shall be provided for padlocking. Each enclosure shall have a print pocket. All wires entering or leaving the enclosure shall terminate on terminal strips. All wires and terminals shall be clearly identified as specified elsewhere in these specifications.
- C. Finish shall be white enamel interior, light gray enamel, ANSI 61 exterior, over phosphatized surfaces. Special finishes and colors shall be furnished for wet locations. Drawings should be checked for special conditions.

2.02 NEMA RATING

- A. Unless otherwise indicated on the Drawings, enclosures shall be NEMA 12 for indoors, NEMA 4X for corrosive areas, and NEMA 4 for outdoor installations. NEMA 4X enclosures shall be stainless steel, unless noted otherwise. NEMA 4 enclosures shall also be used in wet, or wash down areas.

2.03 FIBERGLASS

- A. Enclosures shall be heavy-duty, compression molded, fiberglass reinforced polyester, high impact, heat resistant, NEMA 4X.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Enclosures shall be installed as indicated on the Drawings, and according to manufacturer's instructions.
- B. Enclosures shall be properly grounded, and shall include ground straps connected to hinged doors and accessories.

End of Section

SECTION 16161

CONTROL PANELS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Control panels.
 - 2. Products shall be submitted for review in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.02 QUALITY ASSURANCE

- A. Referenced Standards:
 - 1. American Society for Testing and Materials (ASTM):
 - a. A269, Standard Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service.
 - 2. Joint Industrial Council (JIC):
 - a. EMP-1, Mass Production Equipment.
 - 3. National Electrical Manufacturers Association (NEMA):
 - a. ICS 4, Terminal Blocks for Industrial Use.
 - b. ICS 6, Enclosures for Industrial Controls and Systems.
 - c. 250, Enclosures for Electrical Equipment (1000 V Maximum).
 - 4. National Fire Protection Association (NFPA):
 - a. National Electric Code (NEC).
 - 5. Underwriters Laboratory (UL)
 - a. UL 508A, Standard for Industrial Control Panels
- B. Miscellaneous:
 - 1. Prior to placement of conduit feeds, assure approved control panel layouts available.
 - 2. Assure completely matching color tones for any individual color specified.
 - 3. Provide panel with the required NEMA rating per NEMA Publication No. 250 to meet classifications shown on drawings or specifications.

1.03 SUBMITTALS

- A. Shop Drawings:
 - 1. Scaled panel face and subpanel face instrument and nameplate layout drawings.
 - 2. Panel and subpanel materials of construction.
 - 3. Panel and subpanel dimensions and weights.
 - 4. Panel access openings.
 - 5. Conduit and wiring access locations.
 - 6. Internal wiring and terminal block drawings.

7. Nameplate text.
8. Scaled layouts of any graphic panels.

B. Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Subject to compliance with the Contract Documents, the following manufacturers are acceptable:
1. Enclosures:
 - a. Hoffman
 - b. Rittal
 - c. Hammond
 - d. Or equal.
- B. Submit requests for substitution in accordance with the Contract Documents.

2.02 MATERIALS

- A. Front Panel, Subpanel or Front Door: Steel.
- B. Frame and Bottom Angles: Steel.
- C. Top, Sides, Back, Sides, and Back Door: Steel.
- D. Hinges: Stainless steel.
- E. Nameplates: Phenolic.
- F. Filler Panels: Steel.

2.03 ACCESSORIES

- A. Control Panels:
1. Single function pilot lights.
 - a. Flush, non-protruding.
 - b. Heavy-duty lights with glass lenses.
 - c. Colors:
 - 1) Red: "ON" or "RUNNING."
 - 2) Blue: "REQUIRED" or "STAND-BY."
 - 3) Amber: "Alarm."
 - 4) Green: "OFF" or "STOPPED."
 - d. Lens-type with LED illumination.
- B. Panel Nameplates and Identification:

1. Identify each item on the control panel with rectangular nameplates.
2. Provide nameplates with black letters on white background.
3. Minimum letter height is 1/2 IN for instrument description and 1/4 IN height for instrument tag number.
4. For all panels which have a panel identification number, provide 2 IN high white nameplate with black, 1 IN high lettering with panel identification number.

2.04 FABRICATION

A. General:

1. Fabricate panels with instrument arrangements as shown on the Drawings.
2. Prime control panels with rust inhibitive shop applied primer and paint with two coats of UV resistant white water-based paint.
3. Finish interior of panel with epoxy glass white.
4. Provide control panel which meets the following requirements:
 - a. Panel depth per JIC EMP-1-1967, E7.1.4.
 - b. Door opening per JIC EMP-1-1967, E7.1.5.
 - c. Data pocket per JIC EMP-1-1967, E7.1.6.
 - d. Rigidity per JIC EMP-1-1967, E7.1.7.
 - e. Door alignment and reinforcement per JIC EMP-1-1967, E7.1.8.
 - f. Panel holes and openings per JIC EMP-1-1967, E7.3.2, E7.3.3, and E7.3.4.
 - g. Doors per JIC EMP-1-1967, E7.5.
 - h. Clear panel mounting space per JIC EMP-1-1967, E8.2.9.
 - i. Panel mounted control device location per JIC EMP-1-1967, E8.3.4.
 - j. Clearances in enclosures per JIC EMP-1-1967, E8.4.

B. Free-Standing Panels:

1. Minimum construction thicknesses:
 - a. Front panel, subpanel, or front door with cutouts: 0.123 IN.
 - b. Top, sides, back, filler plates and side or doors with no cutouts: Minimum thickness per, NEMA ICS 6, Tables 3-8,9.
2. Welded construction.
3. Completely enclosed, self-supporting, and gasketed dusttight.
4. Edges turned back minimum of 2 IN.
5. Seams and corners welded and ground smooth to touch and smooth in visual appearance.
6. Arrange control panel faces continuous and flush with face of adjacent electrical motor control centers.
7. Provide filler panels where necessary to close gaps between panels or back of panel and wall. Provide full length flush pan doors.
8. Provide full length piano hinges rated for 1.5 times door plus instrument weight.
9. Furnish doors with keyed alike locking handles and three point catch.
10. Provide appropriate conduit, wiring, and instrument openings in accordance with best panel design.
11. After cutouts have been made, finish opening edges to smooth and true surface condition.

12. Provide each panel with lifting eyebolts. Furnish hot-dipped galvanized steel base channels.
13. Slotted bolt holes in base, 1 1/2 long for field adjustment.

C. Wall Mounted Panels:

1. Minimum construction thicknesses:
 - a. Front panel, subpanel or door with cutouts:
 - 1) Width or height not exceeding 42 IN: 0.093 IN.
 - 2) Width or height exceeding 42 IN: 0.123 IN.
 - b. Side, top, back and doors without cutouts: minimum thickness per NEMA ICS 6, Tables 3-8,9.
2. Seams continuously welded and ground smooth.
3. Body stiffeners for extra rigidity if either height or width exceeds 28 IN.
4. Rolled lip around all sides of enclosure door opening.
5. Gasketed dust tight.
6. Three-point latching mechanism operated by oil tight key-locking handle.
7. Key doors alike.
8. Continuous heavy GA hinge pin on doors.
 - a. Hinges rated for 1.5 times door plus instrument weight.
9. After cutouts have been made, finish opening edges to smooth and true surface condition.
10. Front full opening door.
11. Brackets for wall mounting.

D. Panel Front Construction:

1. Minimum construction thicknesses: per NEMA ICS 6, Tables 3-8,9.
2. Welded construction.
3. Edges turned and ground smooth to touch and visual appearance.
4. At joints where panel face meets side walls, provide dustproof sponge rubber gasket entire height and face.
5. Use full length piano hinges rated for 1.5 times door weight for panel access door.
6. Equip doors with locking devices and handle and three point catches.
7. Finish all instrument cutouts smooth and true.

E. Panel Wiring and Piping:

1. Factory pipe and wire panels to identified terminal blocks equipped with screw type lugs.
2. Install all wiring without splicing in factory in raceways:
 - a. Size raceways per the requirements of NEC Article 312.
 - b. Raceways shall have removable covers.
3. Wire bending space shall be in accordance with Tables 307B, C in NEMA ICS 6.
4. Keep AC power lines separate from low-level DC lines, I/O power supply cables, and all I/O rack interconnect cables.
5. Keep AC signal wires separate from DC signal wires.
6. When I/O wiring must cross AC power wiring, it shall only do so at right angles.

7. Arrange circuits on terminal blocks plus any spare conductors on adjacent terminals.
8. Provide necessary power supplies for control equipment.
9. Equip each panel with a main thermal magnetic circuit breaker. Limit load to maximum of 80 percent of circuit breaker rating.
10. Provide all necessary stabilizing voltage transformers, balancing potentiometers and rectifiers as necessary for specific instrument requirements.
11. Assure each panel mounted device is bonded or otherwise grounded to panel or panel grounding system by means of locknuts or pressure mounting methods.
 - a. Equip panel with grounding terminals.
12. Arrange wiring with sufficient clearance for all leads.
13. Wiring to subpanels or rotary switches shall be individually bundled and installed with a "flexible loop" of sufficient length to permit the component to be removed from panel for maintenance without disconnecting wiring.
14. Identify all wires with plastic sleeve type wire markers at each end. Markers shall:
 - a. Identify circuit numbers.
 - b. Identify function and polarity.
15. Provide all wiring according to color code as follows:

COLOR OF INSULATION	120 V, 60 hZ SERVICE	LOW VOLTAGE DC SERVICE
Black	Phase Conductor	
Red	Signal Wire	
White	Neutral	
Brown		DC Common
Orange		24VDC/12VDC Power
Blue		Signal Wires
Green	Ground	Ground

- a. For intrinsically safe instruments, provide uniform and compatible additional color scheme.
16. Termination requirements:
 - a. Terminal block markings, mechanical characteristics and electrical characteristics shall be in accordance with NEMA ICS 4.
 - b. Terminals shall facilitate wire sizes as follows:
 - 1) 120 V AC applications: Wire size 12 AWG and smaller.
 - 2) Other: Wire size 14 AWG and smaller.
 - c. Provide terminal blocks with continuous marking strip.
 - d. Tag each I/O terminal to indicate tag number of the connected device.
 - e. Provide terminals for individual termination of each signal shield.
 - f. Provide 20 percent excess terminals for future expansion.
17. Pneumatic tubes and appurtenances:
 - a. Provide 1/4 IN OD pneumatic control tubing.
 - b. Main headers within panels shall be minimum 1 IN.
 - c. Compression-type pressure fittings.

- d. Equip panel instrument leads with globe type isolation valve.
- e. Connection to devices not in the panel shall be terminated on tubing terminal plate.
- f. Install tubing neatly and mount securely.
- g. Do not route tubing in front of or in wiring raceways.
- h. Code terminal plates.
- i. Supply and install dual function filter regulator to serve pneumatic devices.

F. Panel Lighting and Power:

- 1. Receptacles:
 - a. Panels less than 4 FT long:
 - 1) One electrical outlet.
 - 2) One incandescent light fixture with switch(es) and separate circuit breakers.
 - b. Panels or panel faces greater than 4 FT long:
 - 1) One electrical outlet per 6 FT of length.
 - 2) Continuous fluorescent lighting strip with switches and separate circuit breakers.

G. Environmental Controls:

- 1. Furnish circulation fans near hot spots where required to prevent temperature from exceeding instrument rating.
- 2. Over-temperature switches shall be utilized to provide special cooling if required to maintain operating temperatures within the manufacturer's specified range.
- 3. Air conditioning applications shall include means of preventing moisture condensation.
- 4. For panels or control cabinets located outside, or in area classification requiring a NEMA 4 or 4X rating:
 - a. Provide printed circuit boards with "Humiseal" conformal coating, covering entire components on both side of board except not covering adjustable components.
 - b. Furnish gold plated edge connectors on circuit board and socket contacts.
 - c. Install thermostatically controlled condensation protection heaters or 10 CU IN desiccant packs in enclosures housing electronic equipment.
 - 1) Provide one pack for each 10 CU FT of panel capacity.

2.05 MAINTENANCE MATERIALS

A. Extra Materials:

- 1. Replacement Bulbs. Provide minimum 25 percent or 25 bulbs, whichever is greater, for replacement indicating light bulbs for each type of indicator furnished in this Project.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install free-standing panels on concrete pads as detailed on the Drawings.
- B. Anchor panel fronts rigidly into wall system with approved anchorage devices.

End of Section

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SECTION 16170

GROUNDING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. A ground grid system consisting of the indicated configuration of copper wires, and ground rods, or concrete encased grounding electrodes ("UFERs") shall be provided to minimize station potential gradient irregularities and drain leakage and fault currents to earth.
- B. Whether indicated on the Drawings or not, neutral conductors, cable shields, metallic conduits, cable terminations, junction boxes, poles, surge arresters, and other noncurrent-carrying metallic parts of equipment shall be grounded.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.03 REFERENCES

- A. National Electrical Code (NEC) Article 250.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. A resistance of not greater than 25 ohms shall be provided, unless otherwise specified. Ground resistances shall be measured as herein described. Resistances of systems requiring separate ground rods, rather than a counterpoise, shall be measured separately before bonding below grade. The combined ground resistance of separate systems bonded together below grade may be used to meet the specified ground resistance, but the minimum number of rods indicated must still be provided.

2.02 GROUND RODS

- A. Ground rods shall be copper-clad steel conforming to UL 467, 3/4 inch in diameter by 10 feet in length. Unless otherwise indicated, ground rods shall be driven into the ground until tops of rods are approximately 6 inches below finished grade. In counterpoise systems, tops of ground rods shall be approximately at elevations of counterpoises. Where the specified ground resistance cannot be met with the indicated number of ground rods, additional ground rods, longer ground rods, or deep-driven sectional rods shall be installed and connected until the specified resistance is obtained, except that not

more than three additional ground rods shall be required at any one installation. Ground rods shall be spaced as evenly as possible at least 6 feet apart and connected below grade.

2.03 CONNECTIONS

- A. Connections above grade shall be made with bolted solderless connectors, and those below grade shall be made by a fusion-welding process. In lieu of a fusion-welding process, a compression ground grid connector of a type which uses a hydraulic compression tool to provide the correct circumferential pressure may be used. Tools and dies shall be as recommended by the manufacturer. An embossing die code or other standard method shall provide visible indication that a connector has been adequately compressed on the ground wire.

2.04 GROUNDING ELECTRODE CONDUCTOR

- A. Service entrance ground wires shall be sized in accordance with NEC Table 250.66, unless otherwise indicated on the Drawings. After being located to provide maximum physical protection, exposed ground wires shall be securely attached to structural supports at not more than 2-foot intervals with suitable fasteners. Bends greater than 45 degrees in ground wires are not permitted. Routing of ground conductors through concrete should be avoided, except where specifically called for in these Documents. When concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit, so as to provide an opening for the ground wire. The opening shall be sealed with a suitable compound after installation of the ground wire.

2.05 EQUIPMENT GROUNDING CONDUCTOR

- A. Neutral conductors shall be grounded where indicated. Equipment grounding conductors shall be sized in accordance with NEC Table 250.122, unless otherwise indicated. Ground wires shall be protected by conduit, where such wires run exposed above grade in nonfence-enclosed areas, or are run through concrete construction. Where concrete penetration is necessary, nonmetallic conduit shall be cast flush with the points of concrete entrance and exit, so as to provide an opening for the ground wire. The opening shall be sealed with a suitable compound after installation of the ground wire. Bends greater than 45 degrees in ground wire connections to the ground rods, or counterpoises are not permitted.

2.06 EQUIPMENT GROUNDING

- A. Equipment frames of motor housings, metallic tanks, metallic equipment enclosures, metal splicing boxes, chain-link fencing, and other metallic noncurrent-carrying metal items, shall be grounded. Connections to earth shall be made in the same manner as required for system grounding. Equipment or devices operating at less than 750 volts may be connected to secondary neutral grounding electrodes.

2.07 SURGE ARRESTER GROUNDING

- A. Surge arresters shall be grounded. Resistance to ground for intermediate-class arresters shall be not more than 10 ohms and for distribution-class arresters shall be not more than 25 ohms. Ground wire connections shall be not less than No. 4 AWG for distribution arresters and No. 1/0 AWG for intermediate arresters. Connections to earth shall be made in the same manner as required for neutral conductors. Surge arrester grounds may use the same ground wires provided for equipment operating at more than 750 volts. Surge arrester and secondary neutral grounds shall be separate from and independent of each other but both grounds shall be bonded together below grade at the ground rods or may utilize a common counterpoise.

2.08 LIGHTING POLE GROUNDING

- A. Base of lighting poles shall be connected to an adjacent ground rod as indicated on Drawings. A ground connection from poles back to neutral ground points shall also be provided utilizing equipment grounding conductor.

2.09 METALLIC STRUCTURES

- A. Metallic structures and buildings shall be grounded per NEC.

2.10 GROUNDING RINGS

- A. When required, grounding rings shall be installed using bare copper cable with ground rods at least 25 feet intervals using thermoweld connecting means as indicated on Drawings in accordance with NEC requirements.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. It is the intent of these Contract Documents that all device and equipment grounds shall be run as a separate conductor in the conduit from the equipment to the distribution panels or system ground. Wireways and enclosures shall be properly bonded and grounded, and ground conductors shall be run for all circuits.
- B. Equipment cases and devices shall be grounded. Ground rods shall be driven, and concrete encased conduits installed, before a building, or structure is built, and ground conductors brought through the concrete to accessible points for grounding equipment. These systems shall be installed at each structure, where transformers, switchboards, panelboards, and MCCs are installed.
- C. Duct banks shall contain a concrete encased system bare copper ground conductor. The system ground conductors shall run continuously in duct banks, through handholes and other raceway boxes. The system ground shall be connected to the structure grounding systems to provide a continuous grounding system. Each metallic raceway, panel,

switchboard, and other metallic devices associated with the electrical and control systems shall be bonded to this grounding system.

- D. Ground rod shall be installed not less than 6 inches below grade. Equipment, neutral, and surge arrester ground wires shall be connected to the ground grid as indicated.

3.02 TESTS

- A. Test the grounding and bonding system in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- B. No part of the electrical system shall be energized until all station grounding system components have been tested and demonstrated to comply with the requirements specified, and until associated test reports have been submitted and approved.

3.03 TEST RESULTS

- A. Perform the above tests and submit a certified test report prior to energizing the equipment.

End Of Section

SECTION 16190

SUPPORTING DEVICES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Supports, anchors, sleeves, and seals, are indicated on the Drawings, schedules, and specified in other sections of these Specifications.
- B. Types of supports, anchors, sleeves and seals specified in this section include the following:
 - 1. One-hole Conduit Straps
 - 2. One-Hole Conduit Straps with Clamp Backs
 - 3. Two-Hole Conduit Straps
 - 4. Conduit Hangers
 - 5. I-beam Clamps
 - 6. Channel Clamps
 - 7. Round Steel Rods
 - 8. Drop-in Anchors
 - 9. Wedge Type Anchor Bolts
 - 10. Lead Expansion Anchors
 - 11. Toggle Bolts
 - 12. Wall and Floor Seals
 - 13. Cable Supports
 - 14. U-Channel Strut System
 - 15. Sleeves

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Acceptable Manufacturers: Subject to compliance with requirements, manufacturers offering products which may be incorporated in the work include, but are not limited to, the following: Abbeon Cal Inc., Ackerman Johnson Fastening Systems Inc., Elcen Metal Products Co., Ideal Industries, Inc., Joslyn Mfg and Supply Co., McGraw Edison Co., Rawlplug Co. Inc., Star Expansion Co., U.S. Expansion Bolt Co., Allied Tube and Conduit Corp., B-Line Systems, Inc., Greenfield Mfg Co., Inc., Midland-Ross Corp., O-Z/Gedney Div; General Signal Corp., Power-Strut Div.; Van Huffer Tube Corp., and Unistrut Div; GTE Products Corp., and Robroy Industries.

2.02 GENERAL

- A. Provide supporting devices that comply with manufacturers standard materials, design, and construction, in accordance with published product information, and as required for complete installations, and as specified herein.

2.03 SUPPORTS

- A. Provide supporting devices of types, sizes, and materials indicated, and having the following construction features:
 - 1. One-Hole Conduit Straps: For supporting electrical metallic tubing, and liquidtight flexible conduit; zinc plated steel, stainless steel or galvanized steel; snap-on, heavy duty.
 - 2. One-Hole Conduit Straps with Clamp Backs: For supporting rigid metal conduit, and intermediate metal conduit; cast galvanized steel.
 - 3. Two-Hole Conduit Straps: For supporting electrical metallic tubing, rigid metal conduit, and intermediate metal conduit; zinc plated steel, stainless steel or galvanized steel.
 - 4. Conduit Hangers: For supporting electrical metallic tubing, rigid metal conduit, and intermediate metal conduit; zinc plated steel, stainless steel or galvanized steel.
 - 5. I-Beam Clamps: Electroplated zinc or hot dipped galvanized malleable iron.
 - 6. Channel Clamps: Electroplated zinc or hot dipped galvanized steel.
 - 7. Round Steel Rod: National coarse thread, electroplated.

2.04 ANCHORS

- A. Provide anchors of types, sizes, and materials indicated, with the following construction features:
 - 1. Lead Expansion Anchors: For CMU walls, 1/4"-20 threads, set tool required.
 - 2. Toggle Bolts: Electroplated steel, size as required.
 - 3. Drop-in Anchors: Stainless steel, size as required.
 - 4. Anchor Bolts: Stainless steel, size as required.
 - 5. Half-round head, non-removable anchor bolts shall not be used.

2.05 SEALS

- A. Provide seals of types, sizes and materials indicated; with the following construction features:
 - 1. Wall and Floor Seals: Provide factory-assembled watertight wall and floor seals, of types and sized indicated; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.
 - 2. Conduit sealing bushings shall be manufactured by O-Z/Gedney, Model CSML, or equal.
 - 3. The conductor sealing bushings shall be manufactured by O-Z/Gedney, Model CSBG, or equal.

2.06 CONDUIT CABLE SUPPORTS

- A. Provide cable supports with insulating wedging plug for non-armored type electrical cables in risers; construct 2" rigid metal conduit; 3-wires, type wire as indicated; construct body of malleable-iron casting with hot-dip galvanized finish.

2.07 U-CHANNEL STRUT SYSTEM

- A. Provide U-channel strut system for supporting electrical equipment, 12-gage hot-dip galvanized steel, of types and sizes indicated; construct with 9/16" dia. holes, 8" o.c. on top surface, with the following fittings that mate and match with U-Channel:
 - 1. Fixture hangers
 - 2. Channel hangers
 - 3. End caps
 - 4. Beam clamps
 - 5. Wiring stud
 - 6. Thinwall conduit clamps
 - 7. Rigid conduit clamps
 - 8. Post Bases
 - 9. U-bolts

2.08 PIPE SLEEVES

- A. Provide pipe sleeves from the following:
 - 1. Steel Pipe: Fabricate from Schedule 40 galvanized steel pipe; remove burrs.

2.09 PVC COATED U-CHANNEL STRUT SYSTEM

- A. Provide PVC Coated U-channel strut system for supporting electrical equipment, 20 mil PVC coated steel, of types and sizes indicated; construct with 9/16" dia. holes, 8" o.c. on top surface, with all Stainless Steel hardware, and the following fittings that mate and match with PVC Coated U-Channel:
 - 1. PVC Coated Strut nut
 - 2. PVC Coated Pipe straps
 - 3. Touch up compound (Gray)

2.10 STAINLESS STEEL U-CHANNEL STRUT SYSTEM

- A. Provide Stainless Steel U-channel strut system for supporting electrical equipment, of types and sizes indicated; construct with 9/16" dia. holes, 8" o.c. on top surface, with all stainless steel hardware, and the following stainless steel fittings that mate and match with Stainless Steel U-Channel:
 - 1. Fixture hangers
 - 2. Channel hangers
 - 3. End caps
 - 4. Beam clamps
 - 5. Wiring stud

6. Post bases
7. Rigid conduit clamps
8. U-bolts

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to insure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installation of supporting devices.
- B. Coordinate with other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Install hangers, supports, clamps and attachments to support piping properly from building structure. Arrange for grouping of 2 or more parallel runs of conduits to be supported together on channel type hangers where possible. Install supports with spacing indicated and in compliance with NEC requirements.
- D. Torque sleeve seal nuts, complying with manufacturer's recommended values. Ensure that sealing grommets expand to form watertight seal.
- E. Comply with manufacturer's recommendations for touch up of field cut ends or damaged PVC coated U-channel and fittings.
- F. Remove burrs and apply a cold zinc galvanizing paint to field cut galvanized U-channel strut.

End of Section

SECTION 16195

ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Electrical identification work specified in this section covers the following:
 - 1. Buried cable warnings
 - 2. Electrical power, control and communication conductors
 - 3. Operational instructions and warnings
 - 4. Danger signs
 - 5. Equipment/system identification signs

1.02 SUBMITTALS

- A. Submittals to the engineer shall include the following:
 - 1. Manufacturers data on electrical identification materials and products
 - 2. Samples of each color, lettering style and other graphic representation required for each identification material or system

1.03 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering electrical identification products maybe incorporated in the work include, but not limited to, the following:
 - 1. Brady, W.H. Co.
 - 2. Ideal Industries, Inc.
 - 3. Panduit Corp.
 - 4. or, equal

1.04 QUALITY COMPLIANCE

- A. Comply with applicable requirements of UL Std. 969, "Marking and Labeling Systems", pertaining to electrical identification systems.
- B. Comply with applicable requirements of NEMA Std. No's WC-1 and WC-2 pertaining to identification of power and control conductors.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an

application, selection is Installer's option, but provide single selection for each application.

2.02 COLOR-CODED CONDUIT MARKERS

- A. Provide manufacturer's standard pre-printed, flexible or semi-rigid, permanent, plastic-sheet conduit markers, extending 360 degrees around conduits; designed for attachment to conduit by adhesive, adhesive lap joint of marker, matching adhesive plastic tape at each end of marker, or pretensioned snap-on. Except as otherwise indicated, provide lettering that indicates voltage of conductor(s) in conduit. Provide 8" minimum length for 2" and smaller conduit, 12" length for larger conduit.
- B. Unless otherwise indicated or required by governing regulations, provide white markers with black letters.

2.03 CABLE AND CONDUCTOR WIRE MARKERS

- A. Cable and conductor wire markers shall be self laminating vinyl on white background, printed using a Brady TLS2200 printer, Seton printer, or equal. Handwritten wire markers are not acceptable.

2.04 SELF-ADHESIVE PLASTIC SIGNS

- A. Provide manufacturer's standard, self-adhesive or pressure-sensitive, pre-printed, flexible vinyl signs for operational instructions or warnings; of sizes suitable for application areas and adequate for visibility, with proper wording for each application, e.g., 208V, EXHAUST FAN, RECTIFIER.
- B. Unless otherwise indicated or required by governing regulations, provide white signs with black lettering.

2.05 LETTERING AND GRAPHICS

- A. Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install electrical identification products as indicated, in accordance with manufacturer's written instructions, and requirements of NEC.

- B. Where identification is to be applied to surfaces that require finish, install identification after completion of painting.
- C. Comply with governing regulations and requests of governing authorities for identification of electrical work.

3.02 CONDUIT IDENTIFICATION

- A. Where electrical conduit is exposed in spaces with exposed mechanical piping that is identified by a color-coded method, apply color-coded identification on electrical conduit in manner similar to piping identification. Except as otherwise indicated, use white as coded color for conduit.

3.03 CABLE/CONDUCTOR IDENTIFICATION

- A. Apply cable/conductor identification, including voltage, phase and feeder number, on each cable/conductor in each box/enclosure/cabinet where wires of more than one circuit or communication/signal system are present, except where another form of identification (such as color-coded conductors) is provided. Match identification with marking system used in panelboards, shop drawings, contract documents, and similar previously established identification for project's electrical work.

3.04 EQUIPMENT/SYSTEM IDENTIFICATION

- A. Install engraved plastic-laminate sign on each major unit of electrical equipment in building; including central or master unit of each electrical system including communication-control-signal systems, unless unit is specified with its own self-explanatory identification or signal system. Except as otherwise indicated, provide single line of text, 1/2" high lettering on 1-1/2" high sign (2" high where 2 lines are required), white lettering in black field. Provide text matching terminology and numbering of the contract documents and shop drawings. Provide signs for each unit of the following categories of electrical work:
 - 1. Panelboards, electrical cabinets and enclosures.
 - 2. Access panel/doors to electrical facilities.
 - 3. Major electrical switchgear.
- B. Install signs at locations indicated or, where not otherwise indicated, at location for best convenience of viewing without interference with operation and maintenance of equipment. Secure to substrate with brass or stainless steel screws, except use adhesive where screws should not or cannot penetrate the substrate.

3.05 CIRCUIT IDENTIFICATION

- A. The 3-phase wires shall be identified at the switchgear, panelboards and motor control centers as Phases A, B, and C. At 277/480V, Phase A shall be brown, Phase B shall be orange, and Phase C shall be yellow. The neutral shall be gray or white.

- B. In addition to color coding all conductors, each conductor shall be identified in each pull box, manhole, panelboard, cable tray, or termination with circuit identification markers. This identification is applicable to all power, control, alarm, and instrumentation conductors and these markings shall be recorded on the Record Documents. Markers shall be slip-on PVC sleeve type as manufactured by Brady, Seton, or equal.
- C. Markers for other cabling shall be B-292 vinyl as manufactured by Brady, Seton, or equal.
- D. Exposed medium voltage conduits shall be labeled at 50-foot intervals with 1-inch letters stating the voltage - example - "12,470 volts". Labels shall be vinyl plastic as manufactured by Brady, Seton, or equal.

3.06 AUTOMATIC EQUIPMENT WARNING SIGNS

- A. Permanent warning signs shall be mounted at all mechanical equipment that may be started automatically or from remote locations. Signs shall be in accordance with OSHA regulations and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the Engineer.
- B. Warning signs shall be 7 inches high by 10 inches wide, colored yellow and black, on not less than 18 gauge vitreous enameling stock. Sign shall read:

CAUTION
THIS EQUIPMENT STARTS
AUTOMATICALLY
BY REMOTE CONTROL

3.07 HIGH VOLTAGE WARNING SIGNS

- A. Permanent and conspicuous warning signs shall be mounted on all equipment, doorways to equipment rooms, pull boxes, manholes, where the voltage exceeds 600 volts.
- B. Signs shall be in accordance with OSHA regulation, and shall be suitable for exterior use. The warning signs shall be fastened with round head brass screws or bolts, located and mounted in a manner acceptable to the Engineer.
- C. Signs shall be 7 inches high by 10 inches wide, colored red and white, on not less than 18 gauge vitreous enameling stock. Sign shall read:

WARNING
HIGH VOLTAGE
KEEP OUT

3.08 CONDUCTOR FASTENERS

- A. Glue-on type conductor fasteners shall not be used in any panels, panelboards, switchboards, switchgear, motor control centers, or other enclosures containing electrical devices and/or conductors.

End of Section

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SECTION 16422

METERED UNDERGROUND SERVICE PEDESTAL

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the metered underground service pedestal and related service equipment.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.
- B. The contractor shall submit shop drawings, catalog cuts, single line diagrams, component layout drawings and equipment elevation. Shop drawings must indicate all ratings, bus bracing, phasing, and utility requirements.
- C. Catalog cuts must be submitted for the service pedestal and components within. Each catalog cut must be properly identified with catalog number and indexed for easy reference.
- D. Single line diagrams must be complete with circuit numbers to match the Drawings. Components must be sized and shown in a bill of materials.
- E. A wiring diagram must be submitted to show connection and control of devices such as ground fault protection, phase protection relays, and other components. Wiring diagram must include component numbers, matching the bill of materials.
- F. Service pedestal must be approved for connection by the serving utility company prior to Engineer's review.
- G. The service pedestal must be UL listed as a complete assembly suitable for Service Entrance Duty.

PART 2 - PRODUCTS

2.01 METERED UNDERGROUND SERVICE PEDESTAL

- A. The service pedestal shall be low profile, vandal resistant, with copper factory wiring.
- B. The service pedestal shall measure approximately 20"W x 18"D x 48"H. The service pedestal shall have a metered distribution section complete with meter socket and factory installed test blocks, and a pull section for underground service entrance, as indicated on the drawings, all of which shall comply with the requirements of the serving utility.

Additionally, the service pedestal shall be provided with a 200 amp, 2 pole, 120/240 volt, main breaker, padlockable in the "off" position.

- C. The enclosure shall be galvanized steel, minimum 10 gauge thickness. Cabinet shall be protected against corrosion in accordance with U.L. 50, Cabinets and Boxes, Section 13. Factory installed components shall be U.L. listed. Factory installed conductors shall be copper, size and type to conform to NEC and U.L. requirements (minimum size #14 AWG). Construction shall be such to prevent the entry of rodents into the interior. Ventilation openings shall be provided.
- D. Unless otherwise indicated on the Drawings, the enclosure shall be rated NEMA 3R for outdoor use. Fasteners shall be stainless steel. All covers shall be padlockable.
- E. Provide breakers and duplex outlets in the control section as shown on the Drawings.
- F. The service pedestal shall have a stainless steel nameplate stamped indicating the equipment voltage, amperage and short circuit withstand rating, mounted on the outside of the enclosure. Also provide a stainless steel address nameplate.
- G. Service pedestal shall be painted with U.V. resistant white paint.
- H. The overcurrent protection shall be rated as indicated, and as specified elsewhere herein.
- I. Metering and instrumentation shall be as indicated, and as specified elsewhere herein.
- J. The service pedestal shall be as manufactured by Myers Model MEUGS, or equal..

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The service pedestal shall be installed per manufacturer's instructions, as indicated on the drawings, per all applicable NEC and local codes and regulations, and shall comply with serving utility's requirements.
- B. Grounding shall be provided as required by the NEC, and as indicated on the Drawings.
- C. Provide a padmount base installed in concrete per manufacturer's requirements.

3.02 TESTING

- A. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.

End of Section

SECTION 16470

PANELBOARDS

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Panelboards furnished in accordance with the Plans and this specification.
 - 1. Service entrance rated main distribution panelboards.
 - 2. Distribution panelboards.
 - 3. Lighting and appliance branch circuit panelboards.
 - 4. Electronic Power Metering on panelboards per Section 2.05, when specified.

1.02 RELATED SECTIONS

- A. Section 16000 – General Electrical Requirements
- B. Section 16195 - Electrical Identification
- C. Section 16505 – Transient Voltage Surge Suppression

1.03 CODES, STANDARDS, AND REGULATORY REQUIREMENTS

- A. All parts, materials, assembly, installation, testing and commissioning shall meet the requirements of the latest edition of the following Codes and Standards, and Regulatory agencies. In case of the conflict between the codes' requirement, the most stringent shall apply.
 - 1. Underwriters' Laboratories:
 - a. Panelboards: UL 67
 - b. Enclosures for Electrical Equipment: UL 50
 - c. Molded Case Circuit breakers and Circuit Breaker Enclosures: UL489
 - 2. FS W-C-375 - Circuit Breakers, Molded Case, Branch Circuit and Service.
 - 3. FS W-P-115 - Power Distribution Panel.
 - 4. NEMA AB 1 - Molded Case Circuit Breakers.
 - 5. NEMA PB 1 - Panelboards.
 - 6. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
 - 7. NEMA PB 1.2 - Application Guide for Ground-fault Protective Devices for Equipment.
 - 8. NFPA 70 - National Electrical Code.
 - 9. UBC - Uniform Building Code.
 - 10. NETA - International Electrical Testing Association.

1.04 SUBMITTALS

- A. Shop drawings for equipment and component devices.

- B. Include outline and support point dimensions, voltage, main bus ampacity, integrated short circuit ampere rating, circuit breaker arrangement, sizes and numbering system.
- C. Include information on all the accessories, locking hardware, shunt trip, under-voltage release mechanism, typical thermal magnetic curves for each size and type.

1.05 SPARE PARTS

- A. Keys: Furnish two door keys for each panelboard.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. General Electric
- B. Siemens – ITE
- C. Square D
- D. Cutler-Hammer
- E. Approved Equal

2.02 BUS AND HARDWARE

- A. Panelboards shall be completely factory assembled and equipped with the type, size and number of branch circuit breakers, arranged and numbered as shown on the Plans. Panelboards shall be fully rated. Series rated panelboards are not acceptable.
- B. All multi-pole breakers shall be common trip. Branch circuits shall be arranged using double row construction. Bus sequence shall be ABC top to bottom, left to right for both top and bottom fed panels. Provisions or space for future breakers shall be located at the bottom of the panel and be fully bussed, complete with all necessary mounting hardware. Use at least 100 ampere breaker-connecting bus straps and mounting hardware.
- C. Where SPARE is indicated on the panel schedule(s), the specified circuit breaker and at least 100 ampere branch-circuit busing and mounting hardware shall be installed.
- D. Where SPACE is indicated on the panel schedule(s), 100 ampere branch-circuit busing and mounting hardware shall be installed, ready for future installation of circuit breakers, furnished by others. At least 20% spare pole spaces, grouped in multiples of three, shall be provided in each panelboard, for future installation by the Owner. Provide single pole filler plates in the spaces, as required.
- E. A nameplate shall be provided, and located near the top of the front trim on the exterior surface, listing panel type and ratings, as required by UL. Each circuit shall be

permanently numbered to agree with the panel schedule, using plastic or metal buttons mounted adjacent to the breaker and secured by rivets or grommets with an engraved or depressed number. Adhesive numbering tape, painted numbers, or use of more than one number per breaker is not acceptable.

- F. Main vertical bus bars shall be copper and silver or tin plated per UL requirements. Bus bars shall be supported by glass-filled polyester-type insulators. All bolts, used to connect current-carrying parts together, shall be accessible for tightening from the front of the panel. Bus bars shall be factory drilled and tapped with spacing arranged to permit breaker interchange, from the front, while the panel is energized.
- G. Neutral bus shall be copper and insulated from the cabinet and all other parts. It shall be rigidly mounted in the panel and shall be provided with a solderless cable connector for each circuit breaker and each space in the panelboard and the main connecting lug(s).
- H. A 1/4-inch (8mm) thick copper equipment ground bus, of sufficient width and length, shall be solidly bolted and grounded to the enclosure at the bottom and shall leave clear space for the bottom cable entries. The bus shall be drilled and tapped for 1/4" (8mm) - #20 machine screws in number to agree with branch circuits and spaces. A solderless connector, for No. 2 to No. 4/0 cable size, shall be bolted to the ground bus.
- I. Copper bus bars shall be of sufficient size to provide a current density of not more than 1000 amperes per square inch of cross section, and not more than 200 amperes per square inch at bolted connections.
- J. Minimum Short Circuit Rating for Bus Bracing: The bus shall be braced for the minimum symmetrical short circuit rating of the panel, as shown on the panel schedule.
- K. Provide main bus pressure connectors (main lugs) and separately supported sub-feed pressure connectors (lug landings) where noted. Provide additional bottom raceway space to accommodate pressure connectors and lug landings. In no instance shall the gutter space be less than required by NFPA-70.
- L. Provide Transient Voltage Surge Suppression where required on Plans.
- M. Where required on Plans, provide re-installed locking devices for locking each circuit breaker in the OPEN position, by means of a padlock. Locking devices shall not be removable from the front of the panel with the trim in place. Attachment of the locking device to the panel with adhesives is not acceptable.

2.03 CIRCUIT BREAKERS

- A. Molded Case Circuit Breakers: NEMA AB 1; provide bolt-on type circuit breakers with integral thermal and instantaneous magnetic trip in each pole and common trip handle for all poles. Provide circuit breakers, UL listed as Type HACR, for air conditioning equipment branch circuits. Provide circuit breakers, UL listed as Type SWD, for lighting

circuits. Provide UL Class A ground fault interrupter circuit breakers where shown on Plans.

- B. Instantaneous magnetic trips shall be accessible and adjustable from the front of the breaker on frame sizes above 100 amperes.
- C. All breakers shall be rigidly mounted, separately removable and independent of trim plates for their support. Breakers shall be bolt on type.
- D. The minimum width of one pole shall be 1-3/8 inches. The breaker shall be "E" frame minimum.
- E. The minimum symmetrical interrupting rating for molded-case circuit breakers shall be as specified on the panel schedule(s). Series rated breakers are not acceptable.

2.04 CABINETS (BOXES)

- A. All details of construction and methods of assembly shall meet the requirements of the "Enclosures for Electrical Equipment" of the Underwriters' Laboratories. The panel box shall not be less than 20" wide, 4.5" deep and of sufficient height to enclose the specified main and branch circuit breakers, buses, metering equipment and wire gutter. The panelboard enclosure shall be fabricated from code-gauge galvanized or galvanized-annealed steel without knockouts and with full front flange. The panel front shall be as shown on the plans and fabricated from cold rolled steel. Surface mounted panel boxes shall be finished with an ANSI-61 light grey baked enamel. There shall be no screws projecting into the wiring raceways. The panelboard enclosure type shall be coordinated with the environment and location shown on the plans. Unless noted otherwise on the panel schedule, provide NEMA 3R for panelboards located out of doors and NEMA 12 elsewhere.
- B. The front trim shall have full-length hinged outer door designed to expose the wiring raceways and breakers, when open. Another, inner hinged door shall expose breakers only, when open, making this a door-in-door construction. Both doors shall open to the right.
- C. Both doors shall be provided with concealed butt or piano hinges. A suitable latch, which can be operated without tools, shall be provided to properly hold the inner door closed. For doors 30 inches (765mm) high or less, a flush-type latch is satisfactory. For doors more than 30 inches (765) high, a vault-type handle shall be provided with a three-point latch that holds the door closed at the top and bottom. The outer door shall be secured with at least four (4) captured oval head machine screws.
- D. A sturdy metal frame, with a clear plastic cover, for an 8-1/2 inch x 11 inch panel schedule, shall be attached inside of the panel door with the RTV adhesive.
- E. Panel trim and doors, and surface mounted cabinets shall be thoroughly cleaned, given a rust-inhibiting treatment, and finished with an ANSI-61 light grey baked enamel.

- F. All panelboards shall bear the Underwriters' Laboratories label.

2.05 ELECTRONIC POWER METERING

- A. The panelboard shall be provided with the electronic power metering, where shown on Plans
 - 1. A digital electronic power shall be used. The meter shall measure the real-time RMS values of the phase currents (Ampere), Ampere demand, phase and line voltages (Volts), KW, KW demand, KWHR, KVA, KVA demand, KVAR, KVAR demand, power factor, and frequency.
 - 2. A communications module shall be provided using an industry standard RS-232 or RS-485 serial bus. Modbus RTU shall be the protocol.
 - 3. The electronic power meter shall have non-volatile memory to record at least 100 time-stamped alarms and events.
 - 4. All potential, control power and current transformers shall be completely installed and wired to the power meter in the panelboard.
 - 5. The electronic power meter shall be Multilin PQM, Siemens Model 4700 Power Meter, Power Measurement Ltd. Model 3710 ACM, or approved equal.

2.06 EXCEPTIONS

- A. The bidders shall list all the exceptions taken from the specification with their quote. If no exceptions are listed with the bid, it is understood that the bidder shall meet all the requirements of this specification and applicable Codes and Standards.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install panelboards plumb and flush with wall finishes, in conformance with NEMA PB 1.1. Where surface mounted, provide suitable supports and rack all branch circuit conduits. Where mounted on concrete wall, install with ½" (15mm) steel spacers behind the panel. All mounting attachments and connections shall be designed in conformance with the minimum lateral seismic force of 0.5W per the most current adopted version of the UBC.
- B. Height: Install top of trim 78 inches above finished floor, unless otherwise noted on drawings.
- C. Provide filler plates for unused spaces in panelboards.
- D. Provide typed or neatly hand printed 8-1/2x11-inch circuit directory for each panelboard, in the format as shown on the drawings. Revise directory to reflect circuiting changes required to balance phase loads.

3.02 QUALITY CONTROL

- A. Owner reserves the right to witness any of the following tests conducted by the contractor and shall be notified in advance of these tests. Test in accordance with Specification 16920 – ELECTRICAL ACCEPTANCE TESTING.
- B. Measure steady state load currents at each panelboard feeder. Should the difference at any panelboard between phases exceed 20 percent, rearrange circuits in the panelboard to balance the phase loads within 20 percent. Maintain proper phasing for multi-wire branch circuits.

3.03 FINAL SUBMITTALS

- A. After completion of the installation, wiring and testing, submit the following information within two weeks of the equipment acceptance.
 - 1. As-Built Panel Schedules.
 - 2. Copy of the certified test report described in Section 3.02.

END OF SECTION

SECTION 16476

LOW VOLTAGE CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall furnish and install, low voltage circuit breakers, as indicated on the Drawings and specified herein.

1.02 SUBMITTALS

- A. Products shall be submitted in accordance with Section 16000, and elsewhere in the Contract Documents, prior to installation.

1.03 QUALITY ASSURANCE

- A. The breaker manufacturer's facilities shall be ISO 9001 certified.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Circuit breakers shall be as manufactured by Square D, Cutler-Hammer, Allen-Bradley, General Electric, or equal.
- B. Circuit breaker frame, trip, short circuit, and interruption ratings shall be as indicated on the Drawings, except that they shall be coordinated with the ratings of the equipment actually furnished, and shall be modified where necessary to suit the equipment. Circuit breakers to be used in motor control centers shall be as indicated on the Drawings. Where no indication of type is given on the Drawings circuit breakers protecting motors shall be motor circuit protectors, and other circuit breakers shall be molded case type.
- C. Circuit breaker for mounting in motor control centers, or for separate mounting shall be of the air-break type, quick-make and quick-break, 600 volt, with number of poles as indicated on the Drawings.
- D. Each pole of the circuit breaker shall provide inverse time delay, and instantaneous circuit protection.
- E. The breakers shall be operated by a handle, and shall have a switching mechanism that is mechanically trip free from the handle, so that the contacts cannot be held closed against short circuits, and abnormal currents. Tripping due to overload, or short circuit shall be clearly indicated by the handle automatically assuming a position between the manual

ON and OFF positions. Latch surfaces shall be ground and polished. Poles shall be constructed so that they open, close, and trip simultaneously.

- F. Breakers must be completely enclosed in a molded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be non-welding silver alloy. Arc extinction must be accomplished by means of arc chutes. The minimum interrupting ratings of the circuit breakers shall be at least equal to the available short circuit current at the line terminals.
- G. Circuit breakers shall conform to the applicable requirements of NEMA Standards Publication No. AB1.
- H. Molded case circuit breakers shall be ambient temperature compensating that provides inverse time delay overload and instantaneous short circuit protection by means of a thermalmagnetic element. Compensation shall be accomplished by a secondary bi-metal that will allow the breaker to carry rated current between 25 degrees C and 50 degrees C with tripping characteristics that are approximately the same throughout this temperature range.
- I. On breakers with interchangeable, thermal, adjustable magnetic trip, the accessibility and position of the adjustment knob shall not be changed from those on the standard breaker.
- J. Unless mounted in a switchboard, or panelboard, circuit breakers shall be housed in a NEMA rated enclosure as described elsewhere in these specifications.
- K. Provide circuit breakers with shunt trip mechanisms where shown on the Drawings.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Circuit breakers shall be installed as indicated on the Drawings and per manufacturer's instructions.

End of Section

SECTION 16477

600 V FUSES

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This section covers the requirements for protective fusing on this project. The Contractor shall furnish and install fuses and fuse holders per the Drawings and equipment manufacturers recommendations.
- B. This specification includes the general requirements for various types of fuses whether they are shown on the Drawings or not. If fusing is required by codes or manufacturers recommendations, but not shown on the Drawings, this specification shall apply to the type of fusing provided by the Contractor.
- C. Types of fuses specified in this section include the following:
 - 1. Class L time-delay.
 - 2. Class L fast-acting.
 - 3. Class RK1 time-delay.
 - 4. Class RK1 and Class J current-limiting.
 - 5. Class RK5 time-delay.
 - 6. Class K5 time-delay, noncurrent-limiting.
 - 7. Class T current-limiting.

1.02 QUALITY ASSURANCE

The fuse manufacturer's facilities shall be ISO 9001 certified.

1.03 CODES AND STANDARDS

- A. UL Compliance and Labeling: Comply with applicable provisions of UL 198D, "High-Interrupting-Capacity Class K Fuses". Provide over-current protective devices which are UL-listed and labeled.
- B. NEC Compliance: Comply with NEC as applicable to construction and installation of fusible devices.
- C. ANSI Compliance: Comply with applicable requirements of ANSI C97.1 "Low-Voltage Cartridge Fuses 600 Volts or Less".

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data on fuses, including specifications, electrical characteristics, installation instructions, furnished specialties and accessories in accordance with Section 16000, and the Contract Documents. In

addition, include voltages and current ratings, interrupting ratings, current limitation ratings, time-current trip characteristic curves, and mounting requirements.

1.05 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering fusible devices which may be incorporated in the work include, but are not limited to, the following: Bussmann, Gould-Shawmut, Reliance, or equal.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Except as otherwise indicated, provide fuses of types, sizes, ratings, and average time-current and peak let-through current characteristics indicated, which comply with manufacturer's standard design, materials, and constructed in accordance with published product information, and with industry standards and configurations.

2.02 CLASS L TIME-DELAY FUSES

- A. Provide UL Class L time-delay fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting transformers, motors, and circuit-breakers.

2.03 CLASS L FAST-ACTING FUSES

- A. Provide UL Class L fast-acting fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting service entrances and main feeder circuit-breakers.

2.04 CLASS RK1 TIME-DELAY FUSES

- A. Provide UL Class RK1 time-delay fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting motors and circuit-breakers.

2.05 CLASS RK1 CURRENT-LIMITING FUSES

- A. Provide UL Class RK1 current-limiting fuses rated 250-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting circuit-breakers.

2.06 CLASS J CURRENT-LIMITING FUSES

- A. Provide UL Class J current-limiting fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating.

2.07 CLASS RK5 TIME-DELAY FUSES

- A. Provide UL Class RK5 time-delay fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protecting motors.

2.08 CLASS K5 ONE-TIME FUSES

- A. Provide UL Class K5 one-time fuses rated 250-volts, 60 Hz, with 100,000 RMS symmetrical interrupting current rating for protecting non-inductive loads.

2.09 CLASS T FUSES

- A. Provide UL Class T fuses rated 600-volts, 60 Hz, with 200,000 RMS symmetrical interrupting current rating for protection of physically small devices.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Fuse types and sizes shall be as indicated on the Drawings. Fuses shall be installed in accordance with the National Electric Code (NEC) requirements and the manufacturer's written instructions.
- B. Install fuses in proper fuse holders.
- C. Where fuses are installed in the motor starters, fuses shall be sized to match the actual motor full load current.
- D. Where fuses are installed in disconnect switches at HVAC units, the fuse sizes shall be sized to meet the HVAC manufacturer's requirements.
- E. Fuses for control transformers shall be sized in accordance with the National Electrical Code.
- F. Fuses shall be installed with the labels clearly visible.

3.02 FIELD QUALITY CONTROL

- A. Prior to energizing fusible devices, test devices for circuit continuity and for short-circuits.

3.03 SPARE PARTS

- A. Furnish 3 spare fuses of each size and type.

End of Section

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SECTION 16500

LIGHTING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. The Contractor shall provide all labor, materials, equipment and incidentals as shown, specified and required to furnish and install lighting fixtures.

1.02 QUALITY ASSURANCE

A. Reference Standards:

1. National Electrical Code (NEC)
2. UL Standard #57, Electric Lighting Fixtures
3. UL Standard #844, Electric Lighting Fixtures for Use in Hazardous Location
4. UL Standard #1570, Fluorescent Lighting Fixtures
5. UL Standard #1571, Incandescent Lighting Fixtures
6. UL Standard #1572, High Intensity Discharge Lighting Fixtures
7. Illuminating Engineering Society (IES)
8. All applicable local lighting ordinances

B. Miscellaneous:

1. Lamps are identified for each luminaire in the Lighting Fixture Schedule on the Drawings.
2. Lighting fixtures and electrical components:
 - a. UL labeled, complete with lamps.
 - b. Rated for area classification as indicated.
3. Location of lighting fixtures on Drawings are intended to be used as a guide.
 - a. Field conditions may affect actual locations.
 - b. Coordinate with other trades to avoid conflicts in mounting of fixtures and other equipment.
4. The quality standard is established by the fixture listed in the Lighting Fixture Schedule.
 - a. This quality standard includes, but is not necessarily limited to construction features, materials of construction, finish, and photometrics.

1.03 SUBMITTALS

A. The following shall be submitted to the Engineer for review:

1. Acknowledgment that products submitted meet requirements of standards referenced.
2. Manufacturer's technical information on products to be used including photometric performance curves for the fixture and ballast data.
3. Acknowledgment that products submitted are UL or ETL listed.

4. When general data sheets constitute part of the submittal, identify the products to be used on this project.
 5. Manufacturer's installation instructions.
 6. Identification of fixtures by Lighting Fixture Schedule.
 7. UL nameplate data (Voltage, wattage, etc.).
 8. Finishes, colors, and mounting type.
 9. Pole, fixture, and accessories.
 10. Pole wind loading.
- B. Contractor shall submit shop drawings, manufacturer's data sheets, and a complete wiring diagram detailing all connections to the electrical system in accordance with Section 16000, and other requirements of the Contract Documents.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Lamps shall be manufactured by General Electric, North American/Phillips, Sylvania, or equal.
- B. Lighting fixtures shall be provided as indicated on the Lighting Fixture Schedule on the Drawings.
- C. Lighting ballasts shall be manufactured by General Electric, Advance, Jefferson, Universal, Bodine, Lithonia, or equal.
- D. Light poles shall be as indicated on the Drawings. Include base template, anchor bolts, cadmium-plated hardware and pole grounding lug, handhole, anchor base and bolt covers. Pole foundations shall be as indicated on the Drawings.

2.02 MATERIALS

- A. General:
 1. Lamps:
 - a. See lighting fixture schedule on Drawings for wattage, voltage and number required.
 2. All Fixtures:
 - a. There shall be no live parts normally exposed to contact.
 - b. When intended for use in wet area:
 - 1) Mark fixtures "suitable for wet locations."
 - c. When intended for use in damp areas:
 - 1) Mark fixtures "suitable for damp locations" or "suitable for wet locations."
 - d. In wet or damp area, install fixtures so that water cannot enter or accumulate in the wiring compartment, lampholder, or other electrical parts.
 - e. Gasket seals: Urethane foam

- f. Diffusers: UV stabilized acrylic plastic
 - 3. Underground wiring:
 - a. Provide all wiring runs with separate green grounding conductor.
 - b. Ground all pole bases.
 - 4. Pole wiring from base to ballast:
 - a. No. 12 type XHHW.
 - b. Each phase shall be protected by a 30A, 600V, type Tron waterproof fuseholder, Bussman "Limitron" type fuse, size rating 3-times load current.
 - B. Incandescent Lamps:
 - 1. Types:
 - a. 30-135 watts: Energy efficient
 - b. 200-500 watts: Standard
 - 2. Inside frost
 - 3. Base: Aluminum or brass
 - 4. PAR/Halogen
 - C. Fluorescent Lamps:
 - 1. Rapid start
 - 2. Cool white (F32T8/41K-85CRI and F96T12/41K-70CRI/HO/ES)
 - 3. Energy efficient or standard as noted on the lighting fixture schedule.
 - D. High-Pressure Sodium Lamps:
 - 1. Bulb finish: Clear
 - 2. Any burning position
 - E. Metal Halide Lamps:
 - 1. Bulb finish: Clear
 - 2. Any burning position
 - F. Furnish a minimum of 2 lamps, or ten percent spare lamps of each type and wattage, whichever is greater.
- 2.03 FIXTURES
- A. Fluorescent Lighting Fixtures:
 - 1. Ballast:
 - a. Rapid start, high power factor type
 - b. CBM/ETL certified
 - c. Sound rating A
 - d. Two internal automatic-resetting thermal switch devices for coil and capacitor
 - 2. Internal wiring: AWM, TFN or THHN
 - 3. Channel and end plates: 22 GA steel
 - 4. Steel door frame and socket track: 20 GA steel
 - 5. Channel cover: 24 GA steel
 - 6. Emergency ballast:

- a. Integral rechargeable nickel-cadmium battery, battery charger, and automatic transfer circuitry.
 - b. Charging indicator light.
 - c. Test Switch.
 - d. Provide a minimum of 900 lumen output for 90 minutes upon loss of normal power.
 - e. Mounted integral to the fixture.
 - f. UL 924 listed.
7. Provide fixtures with emergency ballasts with permanent caution labels warning that the fixture is fed from an unswitched source.
- a. Provide emergency ballast also with a similar caution label.

B. HID Lighting Fixtures:

- 1. Ballasts for high pressure sodium lighting fixtures:
 - a. Type: Regulating
 - b. Ballast design center variance: Maximum 5 percent from rated lamp wattage.
 - c. Lamp wattage regulation spread at the lamp voltage: Maximum 10 percent for +/-10 percent line voltage variation.
 - d. Ballast primary current during starting not to exceed normal operating current.
 - e. Lamp current crest factor: Maximum 1.8 for +/-10 percent line voltage variation at any lamp voltage, from nominal through life.
 - f. Power factor shall not drop below 90 percent for +/-10 percent line voltage variations at any lamp voltage, from nominal through life.
 - g. Capacitor variance: Tolerance of +/-6 percent which will not cause more than a +/-8 percent variation in regulation throughout rated lamp life for nominal line voltage.
 - h. Capable of operation with an open circuit condition for a maximum of 6 months without significant loss of ballast or starting circuitry life.
- 2. Ballasts for metal halide/mercury vapor lighting fixtures:
 - a. Type: Auto-regulator
 - b. Voltage input range: +/-10 percent
 - c. Lamp regulation spread: 20 percent maximum
 - d. Power factor: 90 to 95 percent
 - e. Input voltage dip (4sec.): 40 to 50 percent
 - f. Crest factor of lamp current: 1.6 to 2.0
- 3. Ballasts for exterior HID lamps:
 - a. UL approved
 - b. High power factor designed for -20 Deg F temperature starting
- 4. Fixtures for non-hazardous locations:
 - a. Type: Industrial low bay
 - b. Ballast housing: Die-cast
 - c. Filter: Activated charcoal
 - d. Refractor: UV stabilized molded acrylic

2.04 MISCELLANEOUS ELECTRIC DEVICES

- A. PHOTOELECTRIC CONTROL UNITS shall meet the following requirements:
 - 1. Cadmium sulfide photocell
 - 2. Aluminum weatherproof enclosure
 - 3. 30 amp rated contacts
 - 4. 120-volt AC power
 - 5. The Photoelectric control unit shall be Tork Model 2100, or equal.
- B. MOTION SENSORS shall meet the following requirements:
 - 1. 110 degrees field of view, 60 foot range
 - 2. Adjustable time setting from 15 seconds to 15 minutes
 - 3. Operating temperature of -20 to + 130 degrees F.
 - 4. Complete outdoor, weather proof sensor with complete mounting hardware
 - 5. UL listed
 - 6. The motion sensor(s) shall be manufactured by Leviton Model 50500-H or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install lamps in all luminaires.
- B. Replace all failed fluorescent, incandescent, metal halide, mercury vapor and high pressure sodium lamps with new lamps prior to final acceptance by Owner.
- C. Surface and flush mounted fixtures shall be solidly connected to a junction box. Suspended fixtures shall be hung utilizing pendant mounting or stainless steel chains and hooks. Each suspended fixtures, shall be electrically connected by a length of Type SO flexible cord. 3 conductor No. 14 AWG, minimum, with a twist-lock receptacle mounted in an individual junction box. Plugs and receptacles shall be as manufactured by Hubbell, General Electric Company, or equal.
- D. Provide mounting brackets and/or structural mounting support for fixtures.
 - 1. Do not support fixture from conduit system.
 - 2. Do not support fixture from outlet boxes.
- E. Install with approved mounting hardware following manufacturer's recommendations.
- F. Pole mounted fixtures shall be mounted on steel or aluminum poles as indicated on the Drawings. All metal poles shall be bonded to the facility ground system. Poles shall have adequate handholes and weatherproof receptacles where indicated.
- G. All anchor bolts and nuts shall be stainless steel. Contractor shall paint all steel poles with aluminum paint or other color in accordance with these Contract Documents.

- H. Fixture mounting heights and locations indicated on the Drawings are approximate and are subject to revision in the field where necessary to avoid conflicts and obstructions.

3.02 ADJUSTING AND CLEANING

- A. Wipe all lighting fixture reflectors, lenses, lamps, and trims clean after installation and prior to acceptance of Project by Owner.

End of Section

SECTION 16902

ELECTRICAL CONTROLS, RELAYS, AND ALARMS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This Section includes the following:
 - 1. Pushbutton and Selector Switches
 - 2. Relays
 - 3. Alarms
 - 4. Intrinsic Safety Barriers
 - 5. Wireways
 - 6. Watthour Transducers
 - 7. Elapsed Time Meters and Time Clocks

1.02 RELATED SECTIONS

- A. Section 16000 - General Electrical Requirements
- B. Section 16160 - Enclosures

1.03 REFERENCES

- A. NEMA ICS 1 - General Standards for Industrial Control Systems.
- B. NEMA ICS 2 - Standards for Industrial Control Devices, Controllers and Assemblies.
- C. NEMA ICS 6 - Enclosures for Industrial Controls and Systems.
- D. NEMA ST 1 - Standard for Specialty Transformers (Except General purpose Type).

1.04 SUBMITTALS

- A. Data - a complete list of equipment and material including manufacturer's descriptive data and technical literature, performance charts, catalog cuts and installation instructions, spare parts data for each different item of equipment specified. The data shall include a complete Bill of Materials.
- B. Drawings - containing complete wiring and schematic diagrams, control diagrams, and any other details required to demonstrate that the system has been coordinated and will properly function as a unit. Drawings shall show proposed layout, anchorage, support and appurtenances of equipment and equipment relationship to other parts of the work including clearances for maintenance and operations.

- C. Submit shop drawings in accordance with the Contract Documents, and NEMA ICS 1 specifications indicating control panel layouts, wiring connections and diagrams, dimensions, support points.

1.05 PROJECT RECORD DOCUMENTS

- A. Submit record documents in accordance with the Contract Documents.
- B. Accurately record actual locations of control equipment. Revise diagrams included in Drawings to reflect actual control device connections.

1.06 OPERATION AND MAINTENANCE DATA

- A. Submit operation data in accordance with the Contract Documents.
- B. Include instructions for adjusting and resetting time delay relays, timers, and counters.
- C. Submit maintenance data in accordance with the Contract Documents.
- D. Include recommended preventative maintenance procedures and materials.

PART 2 - PRODUCTS

2.01 PUSHBUTTONS AND SELECTOR SWITCHES

- A. Pushbuttons, pilot lights and selector switches shall be of the full size, heavy-duty industrial, oil tight, 120 volt, with interchangeable pilot lights, plug-in construction, double break silver contacts, chrome plated lock rings, with modular contacts, and NEMA rating equal to that of the enclosure on which devices are installed. All components shall be flush mounted on front of panel, unless otherwise noted.
- B. Provide individual legend plates for indication of switch, pushbutton, and light function (e.g., Open, Closed, Hand-Off-Auto). A list shall be submitted for review and approval.
- C. Pilot lights shall be high intensity LED type. Pilot lights shall have clear lenses and LED lamps colored as shown on the Drawings. Common, remote push-to-test circuitry shall be provided for each control panel to simultaneously test all indicating lights on the panel using a single pushbutton when there are 10 or more lights on the panel. Control panels with less than 10 lights shall utilize individual push-to-test lights and control circuitry.
- D. Pushbuttons shall be maintained or momentary as required and as shown on the Drawings. Provide extended head pushbutton for all stop functions, mushroom head for emergency stop functions, and flush head pushbuttons for all other functions. Where indicated on the Drawings pushbuttons shall be illuminated type. Provide locking mechanism for all lock out functions. Selector switches shall have black knob operator, be maintained contact type unless noted otherwise, number and arrangement as required

to perform intended functions specified but not less than one double pole, double throw, double break contact per switch. Contact rating shall be compatible with AC or DC throughput current of devices simultaneously operated by the switch contact but not less than 10 amperes resistive at 120 volts AC or DC continuous.

- E. Potentiometers shall be provided with operators and resistive elements of the type and quantity indicated on the Drawings and as required with legend plates indicating percent of span.
- F. The above devices shall be manufactured by Square D, Allen Bradley, General Electric, or equal.

2.02 RELAYS

- A. TIMING RELAYS shall be heavy duty, have 250V/5A rated contacts, solid state design, poles as required per application, -10°C to +60°C, have timing repeatability of $\pm 2.0\%$ of setting, and be UL listed. The range shall be determined from the control descriptions and or schematic drawings. Provide mounting accessories, as required. The timing relays shall be manufactured by Allen Bradley, Square D, Cutler Hammer, or equal.
- B. CONTROL RELAYS shall be of the plug-in socket base type with dust-proof plastic enclosures, with silver-cadmium oxide contacts rated 250-volt, 10 amperes, with contact arrangement and operating coils of the proper voltage as required by the control circuit sequence. Relays shall have indicating lamp to show energized state. Each relay shall have a minimum of two double pole, double throw contacts, or as required. Control relays shall be Allen Bradley, Square D, Cutler Hammer, or equal.
- C. ALTERNATING RELAYS shall be UL listed, 120 VAC, with contacts rated for 10 amperes at 250 VAC, life expectancy of 100,000 operations, load indicating LEDs, and switch for load locking and load selecting options. Alternating relays shall be manufactured by TimeMark models 261, 271, and 471, Diversified Electronics model ARA, A.T.C. model "AR", or equal.

2.03 ALARMS

- A. AUDIBLE ALARMS shall be UL listed, 120 VAC, with solid state circuitry, vibrating horn, non-metallic corrosion resistant housing, with required mounting hardware, suitable for outdoor use capable of producing 100 dB at 10 feet. The audible alarm shall be manufactured by Federal Signal model 350, Edwards model 870-EX, or equal.
- B. ROTATING BEACONS for interior and/or exterior locations shall be UL listed, 120 VAC, with motor and cooling fan, rotating lights at 60 times per minute minimum, capable of producing 36000 candlepower with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Federal Signal model 371L or equal.

- C. ROTATING BEACONS for corrosive and/or hazardous locations shall be UL listed, 120 VAC, with solid state circuitry, rotating lights at 60 times per minute minimum, suitable for outdoor use capable of producing 36000 candlepower with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Edwards model 52EX or equal.
- D. STROBE BEACONS shall be UL listed, NEMA 4X, 120 VAC, flashing at 80 times per minute minimum, producing peak candlepower of 520,000, effective candlepower of 165, with required mounting hardware. Lens color shall be verified at the time of construction. The rotating beacons shall be manufactured by Federal Signal model 151XST, Edwards model 92EX, or equal.

2.04 INTRINSIC SAFETY BARRIERS

- A. INTRINSIC SAFETY BARRIERS shall permit connection of devices located in a hazardous area to other devices located in a safe area. Intrinsic safety barriers shall be EMC compliant, 10 to 35 V dc, 35 mA output current, hazardous area terminals identified by blue labels, terminals accommodating conductors up to 12 AWG, ambient temperature rating of -20 to +60°C. The intrinsic safety barriers shall be manufactured by MTL Inc., Ronan Engineering Co., R. Stahl Inc., A.T.C., or equal.

2.05 WIREWAYS

- A. WIREWAYS shall be PVC, snap-in slot design, with non-slip cover. Safe area wireways shall be light gray and marked "Safe Area Wiring." Hazardous area wireways shall be intrinsic blue and marked "Hazardous Area Wiring." The wireways shall be manufactured by Panduit Corporation, or equal.

2.06 WATTHOUR TRANSDUCERS

- A. WATTHOUR TRANSDUCERS for active or reactive power shall be DIN rail and surface mount, single phase or three phase with balanced or unbalanced load, electrically isolated input and output signals, 4 to 20 mA output signal, 0-10 mA to 0-10 A input current, 0-10 V to 0-600 VAC input voltage, 16-500 Hz selectable frequency. The watthour transducers shall be manufactured by Sineax model PQ502, or equal.

2.07 ELAPSED TIME METERS AND TIME CLOCKS

- A. ELAPSED TIME METERS shall be self powered, non-reset, solid state counter which provides silent, accurate and noise immune operation. Elapsed time meters shall require no external power, five year minimum battery life, 120 VAC power, accessories for panel mounting, nameplate below LCD display reading "HOURS", liquid crystal display with 6 digits approximately 2 inches high with 50,000 hour minimum display life and indication of sufficient battery power. The elapsed time meters shall be manufactured by Durant, Automatic Timing and Controls a Division of Sycon Corp., or equal.

- B. TIME CLOCKS shall be microprocessor based, have 24 hour time control, up to 24 operations per day, programmable from panel face keys, skip-a-day feature allowing schedule to be skipped for one to seven days, SPDT switch contact rated at 15 amps at 120 V AC, with battery carryover to maintain time and program during power outage for 275 hours. The time clocks shall be manufactured by Tork, Paragon Electric Company, or equal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Fasteners shall be type 304 stainless steel.
- B. Install devices in strict accordance with NEC requirements and per manufacturers recommendation.
- C. Coordinate with other trades as necessary during installation of these devices.

3.02 ACCEPTANCE

- A. All installations are subject to evaluation in accordance with NEC requirements and manufacturers recommendations. Contractor shall remove the unacceptable work and correct work at no charge to Owner.

End of Section

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SECTION 16920

ELECTRICAL ACCEPTANCE TESTING

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Requirements for electrical acceptance testing of electrical equipment and materials.
2. It is the intent of the tests described herein to assure that all electrical equipment is operational and within industry and manufacturer's tolerances and is installed in accordance with design specifications.
3. Acceptance testing performed by equipment vendors at the point of manufacturer must conform to all requirements of this specification. Testing performed at the point of manufacture which conforms to generally accepted industry practices is also acceptable so long as adequate test result documentation is provided.

B. Scope

1. All of the Acceptance Tests are required to be performed whether they are described in this Section or other applicable Sections. At a minimum, the following electrical systems are to be tested:
 - a. Service Entrance Section
 - b. Main Distribution Panel
 - c. Motor Control Centers
 - d. Switchgear, Low and Medium Voltage
 - e. Panelboards, Power and Lighting/Receptacle
 - f. Transformers, Dry Type and Oil Filled
 - g. Feeders
 - h. Cables rated 600 volts and higher
 - i. Transfer Switches, Manual and Automatic
 - j. Transient Voltage Surge Suppression Systems
 - k. Grounding and Bonding System
 - l. Lighting Fixtures and associated controls
 - m. Other systems as listed under Part 3 of this specification

C. Related Documents

1. Drawings and general provisions of the contract, including General and Supplementary Conditions and other Division 1 Specification sections, apply to the work of this section.
2. All work performed under this Section of the work is subject to all requirements contained under Section 16000 "General Electrical Requirements".
3. All Division 16 specifications for electrical equipment provided for this project that requires electrical acceptance testing.

1.02 REFERENCES

- A. NETA ATS – Acceptance Testing Specifications, 2003 Edition
- B. NFPA 70 – National Electrical Code, 2002 Edition
- C. Incorporated by reference all Codes, Standards, and Specifications referred to in the “APPLICABLE REFERENCES” section of NETA ATS-2003.

1.03 DEFINITIONS

- A. NETA InterNational Electrical Testing Association Inc.
- B. NEC National Electrical Code

1.04 SYSTEM DESCRIPTION

- A. Conditions
 - 1. Provide all items, articles, materials, operations or methods listed, mentioned or scheduled on drawings and/or herein including all labor, materials, equipment and incidentals necessary and required for Electrical Acceptance Testing.
 - 2. Following established procedures, equipment shall be energized after certification by the testing organization that the installation is satisfactory.
 - 3. Correct or replace any current-carrying circuit, electrical equipment, or system which is defective or grounded and correct all other troubles encountered by these tests. All defects, whether through faulty workmanship or materials furnished, shall be corrected under this Section at the Contractors expense.

1.05 SUBMITTALS

- A. Test Report Forms
 - 1. All test reports shall be submitted using NETA or approved similar format and, where appropriate, test forms. Reports shall be legible using permanent ink. Pencil is not acceptable.
 - 2. Provide for engineers review and approval a copy of each test form to be used on the project. No testing shall be started prior to approval of all test forms.
 - 3. All test reports shall include the following information:
 - a. Summary/Description of the Project
 - b. Description of equipment tested.
 - c. Description of the tests.
 - d. Test data and analysis of the data indicating whether the equipment passed or failed the test.
 - 4. All test data records shall include the following minimum requirements:
 - a. Equipment identification including tag numbers.
 - b. Humidity, temperature, and other conditions that may affect the results of the tests and/or calibrations.
 - c. Date of inspections, tests, maintenance, and/or calibrations.

- d. Identification of the testing technician and their employer.
- e. Indication of inspections, tests, maintenance, and/or calibrations to be performed and recorded.
- f. Indication of expected results when calibrations are to be performed.
- g. Indication of "as-found" and "as-left" results, as applicable.
- h. Sufficient spaces to allow all results and comments to be indicated..

B. Closeout Submittals

- 1. Provide one copy each to engineer and owner of all testing reports organized as follows:
 - a. Bind report in 3-ring binder(s).
 - b. Identify project name, description, testing organizations name, and submittal date on front face and back cover of binder.
 - c. Provide all test reports, organized by equipment tag number.
 - d. Separate different equipment numbers with colored or numbered tabs.
 - e. Provide an index/table of contents.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Any materials provided as part of the testing shall be new, unused, and in manufacturer's original packing.

2.02 TEST INSTRUMENT CALIBRATION

- A. Contractor performing the testing shall have a calibration program which assures that all applicable test instruments are maintained within rated accuracy for each test instrument calibrated.
- B. Contractor performing the testing shall maintain up-to-date instrument calibration instructions and procedures for each test instrument calibrated.
- C. It is preferred that instrument calibration accuracy be directly traceable to the national Institute of Standards and Technology (NIST).
- D. Instruments shall be calibrated in accordance with the following frequency schedule:
 - 1. Field instruments: Analog, 6 months maximum. Digital, 12 months maximum
 - 2. Laboratory instruments: 12 months maximum
 - 3. Leased specialty equipment: 12 months maximum.
- E. Dated calibration labels shall be visible on all test equipment.
- F. Records, which show date and results of instruments calibrated or tested, must be kept up to date.

- G. Calibrating standard shall be better accuracy than that of the instrument tested.

PART 3 - EXECUTION

3.01 QUALIFICATIONS

- A. It is preferred that the testing organization shall be an independent, third party entity which can function as an unbiased testing authority, professionally independent of the manufacturers, suppliers, and installers of equipment or systems being evaluated. When such testing organization is used, it must meet the following requirements:
1. The testing organization shall be regularly engaged in the testing of electrical equipment, devices, installations, and systems.
 2. The testing organization shall use technicians who are regularly employed for testing purposes.
 3. The testing organization shall be a member of NETA or be able to prove qualifications equal to or better than required for membership in NETA.
 4. Submit appropriate documentation demonstrating that the testing organization meets the requirements listed above.
 5. Technicians performing these electrical tests and inspections shall be trained and experienced concerning the apparatus and systems being evaluated. These individuals shall be capable of conducting the tests in a safe manner and with complete knowledge of the hazards involved. They must evaluate the test data and make a judgment on the serviceability of the specific equipment.
 6. Technicians shall be certified in accordance with ANSI/NETA ETT-2000, "Standard for Certification of Electrical Testing Personnel". Each on-site crew leader shall hold a current certification, Level III or higher, in electrical testing.
- B. Contractor may perform the electrical acceptance testing under the following conditions:
1. Contractor's personnel performing the testing and their testing equipment meets all other requirements of this specification.
 2. Written approval is received from engineer after review of testing personnel qualifications. At a minimum, contractor's testing personnel must have specific instruction on the testing instruments, accessories, and tests being performed and must be able to evaluate the test results.

3.02 NOTIFICATION

- A. Notify engineer and construction manager at least 2 days prior to testing so that they may be present during testing.

3.03 SAFETY AND PRECAUTIONS

- A. Safety practices shall include, but are not limited to, the following requirements:
1. Occupational Safety and Health Act OSHA
 2. Accident Prevention Manual for Industrial Operations, National Safety Council, Chapter 4

3. Applicable State and Local safety operating procedures
4. NETA Safety/Accident Prevention Program
5. National Fire Protection Association –NFPA 70E
6. ANSI Z244.1 American National Standards for Personnel Protection

- B. All tests shall be performed with apparatus de-energized except where otherwise specifically specified.
- C. The testing firm shall have a designated safety representative on the project to supervise operations with respect to safety.

3.04 EQUIPMENT TESTING REQUIREMENTS

- A. The intent of this specification is not to duplicate testing performed at the point of manufacture or to impose additional burden on the contractor which does not benefit the project. The intent is to verify that electrical equipment has been securely fastened down, supported, and installed in accordance with the manufacturer's requirements. The intent is also to verify that all electrical connections are correctly torqued, properly aligned, properly insulated, and properly supported and that equipment is clean and ready for operation.
- B. Except as noted below or as approved by engineer, test the following equipment and assemblies in full accordance with NETA-ATS 2003.
- C. Switchgear and Switchboard Assemblies
- D. Transformers, Dry Type, Air-Cooled, Low-Voltage, Small
- E. Transformers, Dry Type, Air-Cooled, Large
- F. Transformers, Liquid-Filled
- G. Cables, Low-Voltage, 600 Volt Maximum
1. Perform tests only on cables size #4 AWG and larger.
- H. Cables, Medium-Voltage and High-Voltage
- I. Metal-Enclosed Busways
- J. Switches, Air, Low-Voltage
1. Perform tests only on switches rated 100 amps or higher.
- K. Switches, Air, Medium-Voltage, Metal-Enclosed
- L. Switches, Oil, Medium-Voltage
- M. Switches, Vacuum, Medium-Voltage

- N. Switches, Cutouts
 - 1. Perform tests only on equipment rated 100 amps or higher.
- O. Circuit Breakers, Air, Insulated-Case, Molded-Case
 - 1. Perform visual and mechanical inspections in accordance with NETA for all circuit breakers.
 - 2. Perform electrical tests only on circuit breakers rated 100 amps or higher provided in power distribution and lighting/receptacle panelboards.
 - 3. No testing is required for circuit breakers provided as part of any of the following:
 - a. A UL listed control panel.
 - b. UL listed factory supplied motor control centers.
 - c. Stand-alone combination motor starters.
- P. Circuit Breakers, Air, Medium Voltage
- Q. Circuit Breakers, Oil, Medium Voltage and High Voltage
- R. Circuit Breakers, Vacuum, Medium Voltage
- S. Circuit Switchers
- T. Network Protectors, 600 Volt Class
- U. Protective Relays
- V. Metering Devices
- W. Regulating Apparatus, Voltage, Step and Induction Voltage Regulators
- X. Regulating Apparatus, Load Tap-Changers
- Y. Grounding Systems
- Z. Ground-Fault Protection Systems, Low-Voltage
- AA. Rotating Machinery, AC Motors and Generators
 - 1. Motors provided as part of valve actuators do not require testing.
 - 2. Perform visual and mechanical inspections on all motors.
 - 3. Perform rotation tests on all motors.
 - 4. Perform electrical tests only on motors 50 horsepower and larger.
- BB. Motor Control, Motor Starters, Low-Voltage
- CC. Motor Control, Motor Starters, Medium-Voltage
- DD. Adjustable Speed Drive Systems
- EE. Direct-Current Systems, Batteries, Flooded and Valve-Regulated Lead-Acid

FF. Direct-Current Systems, Chargers

GG. Surge Arresters, Low-Voltage Surge Protection Devices

HH. Surge Arresters, Medium- and High-Voltage Surge Protection Devices

II. Capacitors and Reactors – All Types

JJ. Outdoor Bus Structure

KK. Emergency and Standby Power Systems, Engine Generator

LL. Emergency and Standby Power Systems, UPS

MM. Emergency and Standby Power Systems, Automatic Transfer Switches

NN. Fiber-Optic Cables

3.05 CONSTRUCTION

A. Interface with Other Work

1. Coordinate all testing activities with other disciplines. Retest any equipment disturbed or damaged in any manner after initial testing.

3.06 CLOSEOUT REPORT

A. Provide comprehensive bound test report in accordance with Part 1 of this specification.

End of Section

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SECTION 17000
INSTRUMENTATION

PART 1 - GENERAL

1.01 SUMMARY

A. Section Includes

1. Provide complete instrumentation and control systems as indicated on the Drawings, in the Specifications, and as required by other contract documents. These documents include descriptions of functional operation and performance, as well as standards, but do not necessarily enumerate detailed specifications for all components and devices which are necessary. However, all components and devices shall be furnished and installed as required to provide complete and operable systems for accomplishing the functions and meeting the performance requirements.
2. Scope of work includes:
 - a. Provide all instruments.
 - b. Provide all control panels, PLC panels, SCADA consoles.
 - c. Provide all communication equipment required to make the control system fully operational including but not limited to radios, antennas, switches, routers, hubs, protocol converters, communication cables, and communication racks and power supplies.
 - d. Provide all conduit, conductors, enclosures, materials, and labor to fully interconnect and make operational all control system components.
 - e. Provide power at proper voltage and ampacity to all system components.
 - f. Provide programming for the PLC and SCADA components.
 - g. Provide startup and commissioning assistance
 - h. Train Owner's personnel on proper use and maintenance of the control systems
 - i. Other equipment, materials, and work as necessary to achieve a fully tested and operational control system.

B. Products Supplied But Not Installed Under This Section

1. None

C. Products Installed But Not Supplied Under This Section

1. Instruments and controls provided loose for field installation by packaged equipment or skid-mounted equipment vendors.

D. Related Sections

1. All Division 16 specifications provided for this project.
2. All Division 17 specifications provided for this project.
3. Other division specifications provided for this project as they relate to submittals, concrete, structural, piping/plumbing, mechanical, and HVAC systems.

- E. Allowances
 - 1. Not applicable this section.
- F. Unit Prices
 - 1. Not applicable this section.
- G. Measurement Procedures
 - 1. Not applicable this section.
- H. Special Payment Procedures
 - 1. Not applicable this section.
- I. Alternates/Alternatives
 - 1. All alternates, alternatives, or proposed substitutions of materials or equipment must be approved by ENGINEER.

1.02 REFERENCES

1.03 DEFINITIONS

- A. The word “provide” means “furnish and install”.
- B. PLC means Programmable Logic Controller
- C. SCADA means Supervisory Control and Data Acquisition System

1.04 SYSTEM DESCRIPTION

- A. Design Requirements
 - 1. Using sound engineering principals and current best design practices, provide engineering drawings and design documents specifying system components and detailing their interconnection and installation.
- B. Performance Requirements
 - 1. The instrumentation and control systems shall be furnished and installed complete and ready to operate, including all necessary interconnections and connections to sources of electrical power, air, water, drains and vents, with all required valves, switches and accessories as specified or as recommended for best operation by the manufacturer of the equipment furnished.

1.05 SUBMITTALS

- A. General
 - 1. Submittals for the equipment shall be provided in accordance with Section 16000, and as required elsewhere in the Contract Documents.
- B. Product Data
 - 1. Detailed catalog information for all system components in sufficient detail so that

ENGINEER has sufficient information to determine if the equipment is acceptable for the intended purpose. Minimum information shall be:

- a. Instrument or Equipment tag number
- b. Manufacturer
- c. Model number
- d. Materials of construction
- e. Materials in contact with process fluids
- f. Dimensional information
- g. Weight
- h. Power consumption with required voltage and ampacity
- i. Heat dissipation if greater than 200 watts
- j. Process connection information detailing connection size, type (threaded, flanged, socket weld, etc...)
- k. Recommended mounting details
- l. Recommended spare parts for one year of operation
2. Instrument Data Sheets in ISA S20 format for all instruments.

C. Shop Drawings

1. For complex control systems consisting of mechanical, electrical, and control components, provide the following:
 - a. A Piping and Instrument Diagram in ISA format
 - b. Electrical load calculations with conduit and conductor sizing
2. For integrated control panels or control assemblies, provide the following:
 - a. Dimensioned layout of the control enclosure and mounted equipment and instruments.
 - b. Full bill of material for all components with detailed catalog information on all components.
 - c. 11"x17" fully developed schematic diagram(s) showing power and control wiring, terminal block assignments, and identifying field and enclosure wiring. Provide a drawing index and symbols and legend sheet with all schematics. Show all I/O card details including rack, slot, channel numbers, field termination points, and control power wiring. Label all conductors and identify conductor size and color. Identify all field devices by tag number and by description. Provide over current protection in accordance with NEC requirements.
 - d. 11"x17" instrument loop drawings in ISA format for all analog control loops. Alternatively, multiple loops may be combined on a single analog input or analog output I/O card schematic diagram.
 - e. Nameplate legend
 - f. Paint color and type for painted assemblies
3. Any special installation details.

D. Samples

1. Not applicable for this section

E. Quality Assurance/Control Submittals

1. Design Data, Test Reports

- a. Submit calibration sheets for all field instruments containing the following information:
 - 1) Instrument tag number
 - 2) Instrument manufacturer and model number
 - 3) Person who performed the calibration
 - 4) Manufacturer, model and serial number of the calibrating device
 - 5) Date that calibrating device was last calibrated
 - 6) For analog instruments, process range and associated analog signal in at least 5 increments (For example: 4.00 maDC/0 psig, 8.00 maDC/25 psig, 12.00 maDC/50 psig, 16.00 maDC/75 psig, 20.00 maDC/100 psig)
 - 7) For switches, process values at which the switch changes state and at which the switch resets.
 - 8) For instruments calibrated by manufacturer, manufacturer's calibration report is acceptable as proof of calibration.
 - b. Factory acceptance test reports on all fabricated control panels or assemblies containing the following information:
 - 1) Date of test
 - 2) Test participants
 - 3) Visual inspection of components
 - 4) Successful application of power
 - 5) Validation of all internal wiring
 - 6) Validation of correct control operation
 - 7) Validation of screen graphics or alarm operation (if applicable)
 - 8) Validation of program installation into PLC's and that I/O is functioning properly (if applicable)
 2. Certificates, Manufacturer's
 - a. UL 508 certification for all assembled control panels and assemblies
 3. Instructions, Manufacturer's Field
 - a. Furnish a complete Operations and Maintenance Manual for all assembled control panels and assemblies
 4. Reports
 - a. Not applicable to this section
- F. Closeout Submittals
1. Furnish Operations and Maintenance Manuals in 3-ring binders complete with the following:
 - a. On front and spine of binders provide the project name, owners name and project number.
 - b. Within the binder, identify the contractor and provide contact information
 - c. Inside binders, provide a volume index and table of contents for each binder. Each instrument or control component tag number must be cross referenced to a specific binder tab.
 - d. Furnish manufacturers complete operations and maintenance manuals for all discrete instruments and controls.
 - e. Furnish custom Operations and Maintenance section for each custom control system, control panel, or fabricated assembly.
 - f. Furnish "As-Built" loop and wiring diagrams.